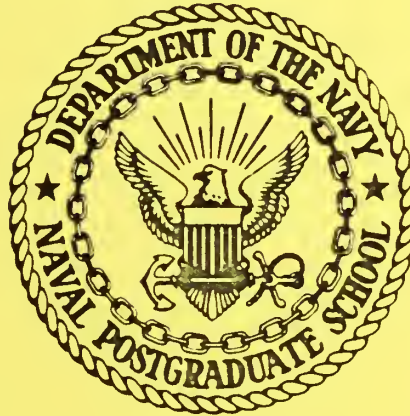# NAVAL POSTGRADUATE SCHOOL
Monterey, California

SOLUTION OF THE LLOYD-MAX QUANTIZER PARAMETERS
BY THE METHOD OF SUCCESSIVE SUBSTITUTION

Paul H. Moose

and

A-A. M. Bassiouni

Prepared for:

Naval Postgraduate School
Monterey, CA 93943

NAVAL POSTGRADUATE SCHOOL
Monterey, California

Rear Admiral R. C. Austin
Superintendent

Kneale T. Marshall
Acting Provost

This report was prepared by:

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b DECLASSIFICATION / DOWNGRADING SCHEDULE	

4 PERFORMING ORGANIZATION REPORT NUMBER(S) NPS-62-88-004	5 MONITORING ORGANIZATION REPORT NUMBER(S)

6a NAME OF PERFORMING ORGANIZATION Naval Postgraduate School	6b OFFICE SYMBOL (If applicable) 62Me	7a NAME OF MONITORING ORGANIZATION

6c ADDRESS (City, State, and ZIP Code) Monterey, CA 93943-5004	7b ADDRESS (City, State, and ZIP Code)

8a NAME OF FUNDING / SPONSORING ORGANIZATION Naval Postgraduate School	8b OFFICE SYMBOL (If applicable)	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c ADDRESS (City, State, and ZIP Code) Monterey, CA 93943	10 SOURCE OF FUNDING NUMBERS			
	PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT ACCESSION NO

11 TITLE (Include Security Classification)

Solution of the Lloyd-Max Quantizer Parameters by the Method of Successive Substitution.

12 PERSONAL AUTHOR(S)

Moose, Paul H. and Bassiouni, A-A. M.

13a TYPE OF REPORT Research	13b TIME COVERED FROM 10/86 TO 11/87	14 DATE OF REPORT (Year, Month, Day) 1987, November 12	15 PAGE COUNT 55

16 SUPPLEMENTARY NOTATION

COSATI CODES			18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

The method of successive substitution is shown applicable to solve for the classical minimum distortion quantizer parameters. The method is self converging and parameters can be calculated to any desired accuracy.

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a NAME OF RESPONSIBLE INDIVIDUAL Paul H. Moose	22b TELEPHONE (Include Area Code) (408) 646-2838	22c OFFICE SYMBOL 62Me

DD FORM 1473, 84 MAR   83 APR edition may be used until exhausted   SECURITY CLASSIFICATION OF THIS PAGE
All other editions are obsolete.

TABLE OF CONTENTS

SOLUTION OF THE LLOYD-MAX QUANTIZER PARAMETERS BY THE METHOD OF SUCCESSIVE SUBSTITUTION

Abstract

The method of successive substitution is shown applicable to solve for the classical minimum distortion quantizer parameters. The method is self converging and parameters can be calculated to any desired accuracy.

A.   INTRODUCTION

The minimum distortion quantizer parameters [Ref. 2,1], as well as parameters based on other criterion such as quantizers for signal detection [Ref. 4], minimum risk quantizers and quantizers for LMMS estimation [Ref. 5] can be solved by Max's trial and error technique [Ref. 2]. There are also many other approximation methods to calculate the quantizer parameters [Refs. 6-8].

In this report we apply the method of successive substitution and its modifications [Ref. 3] to solve for the Lloyd-Max quantizer parameters. It is more accurate and computationally more efficient than the previously reported methods. It is shown to easily generate 7 bit (128 level) optimum quantization.

B.   STATEMENT OF THE PROBLEM

The Lloyd-Max minimum mean square distortion quantizer problem deals with transforming a random variable X of differentiable probability density function $f(x)$ into the N-level discrete random variable Y.

$$Y(X) = Y_i \text{ for } X \in [x_i, x_{i+1}] \tag{eqn 1.1}$$

The optimum parameters minimize the distortion D

$$D = \sum_{i=1}^{N} \int_{x_i}^{x_{i+1}} (x-y_i)^2 \, f(x) \, dx \tag{eqn 1.2}$$

with

$$-\infty = x_1 \leq x_2 \leq \ldots \leq x_N \leq x_{N+1} = \infty$$

Differentiating D with respect to x_i and y_i yields the following necessary conditions of optimality :

$$x_i = (y_i + y_{i+1})/2 \quad ,i = 2,3,...N \qquad \text{(eqn 1.3)}$$

$$y_i = (\int_{x_i}^{x_{i+1}} xf(x)dx)/(\int_{x_i}^{x_{i+1}} f(x)dx) \quad ,i = 1,2,...N \qquad \text{(eqn 1.4)}$$

a set of simultaneous equations of propagating character. That is, if y_1 is chosen correctly then x_2 can be calculated from (1.4), y_2 from (1.3), x_3 from (1.4) and so forth [Ref. 2]. In this case the value of y_N calculated from (1.3) must agree with its value calculated from (1.4) with $x_{N+1} = \infty$. This was the core of Max's trial and error algorithm; to pick a value for y_1 and calculate the parameters up to and including y_N, which must agree with the value of y_N calculated from (1.4), otherwise, to pick another value of y_1. Let us put the system of equations in the form

$$\underline{Z} = \underline{G}(\underline{Z}) \qquad \text{(eqn 1.5)}$$

where $\underline{Z}$ is a 2N-1 vector given by:

$$\underline{Z} = [\, y_1 \; x_2 \; y_2 \; .....y_N \,]^t \qquad \text{(eqn 1.6)}$$

and apply the iterative substitution

$$\underline{Z}_{new} = \underline{G}(\underline{Z}_{old}) \qquad \text{(eqn 1.7)}$$

with a suitable initial guess. The convergence is guaranteed if $\partial G_k / \partial Z_j$ is sufficiently small for every $k,j = 1,2,...,2N-1$ [Ref. 3]. From (1.4)

$$\partial G_j / \partial y_j = [(x_{j+1} - y_j)f(x_{j+1}) + (y_j - x_j)f(x_j)]/(2P_j) \qquad \text{(eqn 1.8)}$$

where P_j is the probability the input of the quantizer is in the j_{th} interval.

$$P_j = \int_{x_j}^{x_{j+1}} f(x)dx. \qquad\qquad\qquad\text{(eqn 1.9)}$$

The numerator in (1.8) is an approximation of the integral in (1.9) by the trapezoidal rule with the subdivision $[x_j, y_j, x_{j+1}]$, so the value of the derivative is very likely less than one. Also, substituting for y_j and y_{j+1} in (1.3) from (1.4) and differentiating with respect to x_j it is easily to show that

$$\partial\, G_j / \partial\, x_j = (y_j - x_j)f(x_j)/(2P_j) + (x_j - y_{j-1})f(x_j)/2P_{j-1} \qquad\text{(eqn 1.10)}$$

which is less than $(\partial\, G_j / \partial\, y_j)$. The method can be more efficient if we use the updated values in the same iteration. In this modification of the method the best current values of the parameters are used. This choice may also enhance convergence. The method also avoids the tedious calculation of the upper limit of the integral to solve for the next x_j in (1.4). A FORTRAN program is included as Appendix A.

C.   NUMERICAL RESULTS.

We have solved for the quantizer parameters for a standard normal random variable of zero mean and unit variance for values of N up to 128. Also the mean square error D and the output entropy $(-\sum_k P_k \log_2 (P_k))$ have been calculated. The results presented in Table 1 show that in several cases Max's results, which were only available up to N = 36, are not accurate in the last digit.

Key to Table 1

The numbering in the table is as follows:

1.   For N even, each table begins with the $(N/2+1)_{th}$ parameters. In this case the $(N/2+1)_{th}$ value of x is zero.

2.   For N odd, each table begins with the $(N/2+2)_{th}$ parameters. In this case the $(N/2+2)_{th}$ value of y is zero.

Negative parameters can be calculated from the symmetry relations

$$X_j = -X_{n-j+2} \qquad\qquad\qquad\text{(eqn 1.11)}$$

and

$$y_j = -y_{n-j+1}. \qquad\qquad\qquad\text{(eqn 1.12)}$$

3

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION

N = 2

J	X	Y
2	0.000000	0.797885

ERROR = 0.363380
ENTROPY = 1.000000

N = 3

J	X	Y
2	-0.612003	0.000000
3	0.612003	1.224006

ERROR = 0.190174
ENTROPY = 1.535789

N = 4

J	X	Y
3	0.000000	0.452780
4	0.981599	1.510418

ERROR = 0.117482
ENTROPY = 1.911099

N = 5

J	X	Y
3	-0.382284	0.000000
4	0.382284	0.764567
5	1.244357	1.724147

ERROR = 0.079941
ENTROPY = 2.202916

N = 6

J	X	Y
4	0.000000	0.317716
5	0.658911	1.000106
6	1.446850	1.893595

ERROR = 0.057978
ENTROPY = 2.442789

N = 7

J	X	Y
4	-0.280289	0.000000
5	0.280288	0.560577
6	0.874362	1.188147
7	1.610758	2.033369

ERROR = 0.044000

ENTROPY = 2.646931

N = 8

J	X	Y
5	0.000000	0.245094
6	0.500550	0.756005
7	1.049957	1.343909
8	1.747927	2.151946

ERROR = 0.034548
ENTROPY = 2.824865

N = 9

J	X	Y
5	-0.221819	0.000000
6	0.221819	0.443639
7	0.681217	0.918796
8	1.197594	1.476392
9	1.865528	2.254664

ERROR = 0.027853
ENTROPY = 2.982695

N = 10

J	X	Y
6	0.000000	0.199623
7	0.404740	0.609857
8	0.833841	1.057825
9	1.324583	1.591340
10	1.968218	2.345096

ERROR = 0.022937
ENTROPY = 3.124584

N = 11

J	X	Y
6	-0.183729	0.000000
7	0.183729	0.367458
8	0.559913	0.752367
9	0.965597	1.178826
10	1.435733	1.692639
11	2.059193	2.425746

ERROR = 0.019220
ENTROPY = 3.253506

N = 12

J	X	Y
7	0.000000	0.168438
8	0.340142	0.511846
9	0.694313	0.876779
10	1.081245	1.285711
11	1.534371	1.783030
12	2.140733	2.498435

ERROR = 0.016340
ENTROPY = 3.371666

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 13

J	X	Y
7	-0.156887	0.000000
8	0.156887	0.313773
9	0.476012	0.638251
10	0.812600	0.986949
11	1.184106	1.381263
12	1.622890	1.864518
13	2.214522	2.564525

ERROR = 0.014063
ENTROPY = 3.480744

N = 14

J	X	Y
8	0.000000	0.145706
9	0.293513	0.441321
10	0.595882	0.750443
11	0.918039	1.085635
12	1.276582	1.467528
13	1.703070	1.938612
14	2.281837	2.625062

ERROR = 0.012232
ENTROPY = 3.582050

N = 15

J	X	Y
8	-0.136929	0.000000
9	0.136928	0.273857
10	0.414310	0.554764
11	0.702949	0.851134
12	1.013007	1.174879
13	1.360468	1.546057
14	1.776266	2.006474
15	2.343670	2.680866

ERROR = 0.010737
ENTROPY = 3.676630

N = 16

J	X	Y
9	0.000000	0.128395
10	0.258222	0.388048
11	0.522404	0.656759
12	0.799550	0.942340
13	1.099286	1.256231
14	1.437139	1.618046
15	1.843532	2.069017
16	2.400803	2.732590

ERROR = 0.009501
ENTROPY = 3.765328

N = 17

J	X	Y
9	-0.121497	0.000000
10	0.121497	0.242994
11	0.366938	0.490882
12	0.620085	0.749287
13	0.887442	1.025597
14	1.178246	1.330896
15	1.507669	1.684442
16	1.905707	2.126971
17	2.453866	2.780762

ERROR = 0.008467
ENTROPY = 3.848840

N = 18

J	X	Y
10	0.000000	0.114769
11	0.230557	0.346345
12	0.465324	0.584302
13	0.709082	0.833862
14	0.967981	1.102100
15	1.250963	1.399827
16	1.572915	1.746003
17	1.963465	2.180927
18	2.503372	2.825817

ERROR = 0.007593
ENTROPY = 3.927741

N = 19

J	X	Y
10	-0.109205	0.000000
11	0.109204	0.218409
12	0.329382	0.440355
13	0.555076	0.669797
14	0.790731	0.911666
15	1.042234	1.172801
16	1.318296	1.463791
17	1.633568	1.803345
18	2.017359	2.231373
19	2.549745	2.868116

ERROR = 0.006848
ENTROPY = 4.002518

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 20

J	X	Y
11	0.000000	0.103762
12	0.208277	0.312791
13	0.419640	0.526488
14	0.637511	0.748533
15	0.866088	0.983642
16	1.111055	1.238467
17	1.380941	1.523414
18	1.690196	1.856977
19	2.067846	2.278714
20	2.593337	2.907961

ERROR = 0.006208
ENTROPY = 4.073583

N = 21

J	X	Y
11	-0.099179	0.000000
12	0.099178	0.198357
13	0.298856	0.399355
14	0.502624	0.605892
15	0.713667	0.821442
16	0.935997	1.050552
17	1.175138	1.299725
18	1.439469	1.579214
19	1.743269	1.907323
20	2.115306	2.323289
21	2.634448	2.945607

ERROR = 0.005653
ENTROPY = 4.141290

N = 22

J	X	Y
12	0.000000	0.094686
13	0.189942	0.285198
14	0.382215	0.479232
15	0.579359	0.679485
16	0.784380	0.889276
17	1.001147	1.113019
18	1.235056	1.357093
19	1.494358	1.631622
20	1.793180	1.954739
21	2.160062	2.365386
22	2.673330	2.981274

ERROR = 0.005170
ENTROPY = 4.205942

N = 23

J	X	Y
12	-0.090844	0.000000
13	0.090844	0.181688
14	0.273544	0.365400
15	0.459363	0.553325
16	0.650668	0.748012
17	0.850333	0.952654
18	1.062107	1.171561
19	1.291284	1.411007
20	1.546005	1.681003
21	1.840265	1.999527
22	2.202390	2.405252
23	2.710201	3.015150

ERROR = 0.004746
ENTROPY = 4.267806

N = 24

J	X	Y
13	0.000000	0.087072
14	0.174587	0.262101
15	0.350977	0.439853
16	0.531112	0.622370
17	0.717227	0.812084
18	0.912088	1.012091
19	1.119352	1.226612
20	1.344223	1.461834
21	1.594750	1.727666
22	1.884807	2.041948
23	2.242523	2.443098
24	2.745248	3.047398

ERROR = 0.004372
ENTROPY = 4.327112

N = 25

J	X	Y
13	-0.083805	0.000000
14	0.083805	0.167610
15	0.252208	0.336806
16	0.423045	0.509283
17	0.598128	0.686972
18	0.779592	0.872212
19	0.970115	1.068019
20	1.173279	1.278540
21	1.394213	1.509886
22	1.640881	1.771876
23	1.927050	2.082224
24	2.280667	2.479110
25	2.778634	3.078159

ERROR = 0.004041
ENTROPY = 4.384064

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 26		
J	X	Y
14	0.000000	0.080593
15	0.161536	0.242480
16	0.324498	0.406516
17	0.490402	0.574288
18	0.660961	0.747635
19	0.838229	0.928823
20	1.024813	1.120803
21	1.224230	1.327657
22	1.441544	1.555432
23	1.684648	1.813865
24	1.967207	2.120549
25	2.316997	2.513445
26	2.810502	3.107559

	ERROR	=	0.003746
	ENTROPY	=	4.438843

N = 27		
J	X	Y
14	-0.077781	0.000000
15	0.077780	0.155561
16	0.233975	0.312389
17	0.392106	0.471823
18	0.553594	0.635364
19	0.720073	0.804782
20	0.893532	0.982281
21	1.076518	1.170756
22	1.272495	1.374235
23	1.486469	1.598704
24	1.726267	1.853829
25	2.005461	2.157093
26	2.351670	2.546247
27	2.840977	3.135707

	ERROR	=	0.003483
	ENTROPY	=	4.491610

N = 28		
J	X	Y
15	0.000000	0.075012
16	0.150307	0.225602
17	0.301760	0.377919
18	0.455569	0.533219
19	0.613076	0.692934
20	0.775854	0.858775
21	0.945836	1.032897
22	1.125522	1.218147
23	1.318326	1.418505
24	1.529205	1.639905
25	1.765925	1.891945
26	2.041975	2.192005
27	2.384821	2.577637
28	2.870169	3.162701

	ERROR	=	0.003246
	ENTROPY	=	4.542507

N = 29		
J	X	Y
15	-0.072566	0.000000
16	0.072566	0.145132
17	0.218211	0.291291
18	0.365424	0.439557
19	0.515338	0.591119
20	0.669236	0.747352
21	0.828638	0.909923
22	0.995431	1.080939
23	1.172074	1.263209
24	1.361940	1.460671
25	1.569941	1.679211
26	1.803788	1.928364
27	2.076890	2.225415
28	2.416571	2.607727
29	2.898177	3.188627

	ERROR	=	0.003032
	ENTROPY	=	4.591663

N = 30		
J	X	Y
16	0.000000	0.070155
17	0.140542	0.210928
18	0.282019	0.353110
19	0.425412	0.497714
20	0.571795	0.645876
21	0.722402	0.798927
22	0.878709	0.958490
23	1.042565	1.126640
24	1.216393	1.306147
25	1.403530	1.500912
26	1.608846	1.716779
27	1.840001	1.963224
28	2.110332	2.257440
29	2.447027	2.636614
30	2.925088	3.213562

	ERROR	=	0.002839
	ENTROPY	=	4.639193

7

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N =	31	
J	X	Y
16	-0.068008	0.000000
17	0.068008	0.136016
18	0.204446	0.272876
19	0.342170	0.411464
20	0.482101	0.552739
21	0.625267	0.697794
22	0.772858	0.847921
23	0.926315	1.004710
24	1.087456	1.170202
25	1.258670	1.347138
26	1.443261	1.539385
27	1.646065	1.752745
28	1.874694	1.996643
29	2.142413	2.288184
30	2.476285	2.664385
31	2.950981	3.237577

ERROR   =   0.002664
ENTROPY =   4.685201

N =	32	
J	X	Y
17	0.000000	0.065890
18	0.131971	0.198052
19	0.264715	0.331378
20	0.399039	0.466699
21	0.535816	0.604934
22	0.676035	0.747136
23	0.820850	0.894565
24	0.971674	1.048783
25	1.130294	1.211804
26	1.299072	1.386340
27	1.481284	1.576228
28	1.681731	1.787233
29	1.907981	2.028728
30	2.173234	2.317739
31	2.504429	2.691120
32	2.975926	3.260732

ERROR   =   0.002505
ENTROPY =   4.729784

N =	33	
J	X	Y
17	-0.063990	0.000000
18	0.063989	0.127979
19	0.192320	0.256661
20	0.321719	0.386777
21	0.452946	0.519114
22	0.586835	0.654557
23	0.724342	0.794128
24	0.866594	0.939060
25	1.014974	1.090888
26	1.171246	1.251604
27	1.337749	1.423893
28	1.517729	1.611565
29	1.715958	1.820352
30	1.939964	2.059577
31	2.202883	2.346189
32	2.531538	2.716887
33	2.999987	3.283086

ERROR   =   0.002359
ENTROPY =   4.773025

N =	34	
J	X	Y
18	0.000000	0.062113
19	0.124387	0.186661
20	0.249422	0.312182
21	0.375774	0.439366
22	0.504166	0.568966
23	0.635400	0.701834
24	0.770402	0.838970
25	0.910276	0.981581
26	1.056382	1.131182
27	1.210461	1.289741
28	1.374831	1.459921
29	1.552714	1.645507
30	1.748853	1.852198
31	1.970736	2.089274
32	2.231441	2.373609
33	2.557680	2.741751
34	3.023220	3.304689

ERROR   =   0.002226
ENTROPY =   4.815004

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 35

J	X	Y
18	-0.060420	0.000000
19	0.060420	0.120840
20	0.181556	0.242272
21	0.303590	0.364907
22	0.427154	0.489401
23	0.552939	0.616478
24	0.681721	0.746965
25	0.814402	0.881839
26	0.952063	1.022287
27	1.096045	1.169804
28	1.248071	1.326339
29	1.410437	1.494535
30	1.586344	1.678153
31	1.780507	1.882861
32	2.000379	2.117898
33	2.258981	2.400065
34	2.582918	2.765771
35	3.045679	3.325587

ERROR   = 0.002104
ENTROPY = 4.855793

N = 36

J	X	Y
19	0.000000	0.058747
20	0.117630	0.176512
21	0.235806	0.295100
22	0.355094	0.415088
23	0.476096	0.537104
24	0.599475	0.661847
25	0.725985	0.790123
26	0.856506	0.922889
27	0.992102	1.061315
28	1.134096	1.206878
29	1.284194	1.361509
30	1.444672	1.527835
31	1.618713	1.709591
32	1.811006	1.912420
33	2.028969	2.145518
34	2.285569	2.425621
35	2.607309	2.788998
36	3.067411	3.345823

ERROR   = 0.001991
ENTROPY = 4.895457

N = 37

J	X	Y
19	-0.057229	0.000000
20	0.057228	0.114457
21	0.171937	0.229416
22	0.287406	0.345396
23	0.404171	0.462946
24	0.522808	0.582670
25	0.643958	0.705246
26	0.768354	0.831462
27	0.896860	0.962258
28	1.030524	1.098789
29	1.170652	1.242515
30	1.318934	1.395353
31	1.477631	1.559910
32	1.649906	1.739903
33	1.840425	1.940946
34	2.056573	2.172199
35	2.311265	2.450331
36	2.630905	2.811480
37	3.088458	3.365436

ERROR   = 0.001888
ENTROPY = 4.934058

N = 38

J	X	Y
20	0.000000	0.055727
21	0.111570	0.167413
22	0.223606	0.279799
23	0.336588	0.393377
24	0.451025	0.508673
25	0.567472	0.626270
26	0.686549	0.746829
27	0.808975	0.871121
28	0.935596	1.000071
29	1.067445	1.134820
30	1.205818	1.276815
31	1.352387	1.427958
32	1.509400	1.590841
33	1.680000	1.769160
34	1.868833	1.968505
35	2.083252	2.197998
36	2.336122	2.474247
37	2.653754	2.833261
38	3.108861	3.384461

ERROR   = 0.001792
ENTROPY = 4.971649

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 39		
J	X	Y
20	-0.054358	0.000000
21	0.054357	0.108715
22	0.163288	0.217860
23	0.272869	0.327878
24	0.383557	0.439236
25	0.495838	0.552440
26	0.610249	0.668057
27	0.727394	0.786731
28	0.847976	0.909220
29	0.972828	1.036437
30	1.102972	1.169508
31	1.239688	1.309869
32	1.384639	1.459408
33	1.540055	1.620702
34	1.709065	1.797429
35	1.896293	1.995157
36	2.109062	2.222968
37	2.360191	2.497415
38	2.675898	2.854381
39	3.128656	3.402931
ERROR =	0.001703	
ENTROPY =	5.008284	

N = 41		
J	X	Y
21	-0.051761	0.000000
22	0.051761	0.103522
23	0.155469	0.207416
24	0.259739	0.312062
25	0.364961	0.417860
26	0.471551	0.525241
27	0.579961	0.634681
28	0.690699	0.746717
29	0.804344	0.861970
30	0.921571	0.981172
31	1.043194	1.105216
32	1.170210	1.235205
33	1.303880	1.372554
34	1.445841	1.519128
35	1.598301	1.677474
36	1.764357	1.851240
37	1.948594	2.045947
38	2.158280	2.270613
39	2.406144	2.541674
40	2.718229	2.894784
41	3.166553	3.438322
ERROR =	0.001545	
ENTROPY =	5.078870	

N = 40		
J	X	Y
21	0.000000	0.053003
22	0.106105	0.159207
23	0.212610	0.266014
24	0.319928	0.373842
25	0.428491	0.483140
26	0.538769	0.594398
27	0.651282	0.708166
28	0.766620	0.825075
29	0.885473	0.945871
30	1.008663	1.071455
31	1.137199	1.202942
32	1.272350	1.341757
33	1.415766	1.489775
34	1.569667	1.649559
35	1.737165	1.824771
36	1.922862	2.020954
37	2.134056	2.247159
38	2.383518	2.519877
39	2.697377	2.874878
40	3.147876	3.420875
ERROR =	0.001621	
ENTROPY =	5.044010	

N = 42		
J	X	Y
22	0.000000	0.050532
23	0.101151	0.151770
24	0.202649	0.253528
25	0.304849	0.356170
26	0.408125	0.460079
27	0.512875	0.565671
28	0.619541	0.673410
29	0.728616	0.783821
30	0.840668	0.897514
31	0.956364	1.015213
32	1.076507	1.137800
33	1.202085	1.266370
34	1.334349	1.402327
35	1.474926	1.547526
36	1.626014	1.704502
37	1.790695	1.876887
38	1.973535	2.070182
39	2.181777	2.293372
40	2.428107	2.562841
41	2.738486	2.914131
42	3.184714	3.455297
ERROR =	0.001474	
ENTROPY =	5.112906	

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 43

J	X	Y
22	-0.049402	0.000000
23	0.049402	0.098804
24	0.148367	0.197930
25	0.247820	0.297709
26	0.348098	0.398487
27	0.449560	0.500632
28	0.552591	0.604551
29	0.657622	0.710693
30	0.765133	0.819574
31	0.875685	0.931797
32	0.989936	1.048075
33	1.108678	1.169281
34	1.232893	1.296504
35	1.363821	1.431138
36	1.503082	1.575026
37	1.652860	1.730694
38	1.816226	1.901759
39	1.997729	2.093700
40	2.204587	2.315474
41	2.449443	2.583412
42	2.758180	2.932948
43	3.202386	3.471824

ERROR = 0.001407
ENTROPY = 5.146156

N = 44

J	X	Y
23	0.000000	0.048282
24	0.096640	0.144997
25	0.193582	0.242167
26	0.291136	0.340105
27	0.389624	0.439143
28	0.489391	0.539639
29	0.590812	0.641986
30	0.694306	0.746626
31	0.800346	0.854066
32	0.909482	0.964898
33	1.022364	1.079830
34	1.139779	1.199727
35	1.262698	1.325669
36	1.392355	1.459041
37	1.530360	1.601679
38	1.678888	1.756097
39	1.840997	1.925897
40	2.021218	2.116539
41	2.226746	2.336952
42	2.470185	2.603417
43	2.777339	2.951262
44	3.219593	3.487924

ERROR = 0.001345
ENTROPY = 5.178655

N = 45

J	X	Y
23	-0.047248	0.000000
24	0.047248	0.094497
25	0.141886	0.189276
26	0.236950	0.284625
27	0.332735	0.380845
28	0.429551	0.478256
29	0.527730	0.577204
30	0.627639	0.678074
31	0.729686	0.781298
32	0.834337	0.887375
33	0.942134	0.996892
34	1.053719	1.110547
35	1.169873	1.229199
36	1.291560	1.353920
37	1.420005	1.486090
38	1.556811	1.627533
39	1.704143	1.780753
40	1.865047	1.949341
41	2.044038	2.138736
42	2.248288	2.357840
43	2.490362	2.622884
44	2.795991	2.969098
45	3.236358	3.503619

ERROR = 0.001287
ENTROPY = 5.210437

N = 46

J	X	Y
24	0.000000	0.046224
25	0.092514	0.138804
26	0.185294	0.231783
27	0.278609	0.325435
28	0.372741	0.420048
29	0.467990	0.515932
30	0.564679	0.613425
31	0.663163	0.712902
32	0.763845	0.814788
33	0.867182	0.919576
34	0.973710	1.027844
35	1.084065	1.140286
36	1.199020	1.257753
37	1.319532	1.381311
38	1.446821	1.512331
39	1.582481	1.652630
40	1.728667	1.804704
41	1.888415	1.972127
42	2.066225	2.160324
43	2.269245	2.378167
44	2.510004	2.641842
45	2.814160	2.986478
46	3.252702	3.518926

ERROR = 0.001233
ENTROPY = 5.241533

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION

N = 47				N = 49		
J	X	Y		J	X	Y
24	-0.045275	0.000000		25	-0.043460	0.000000
25	0.045275	0.090550		26	0.043460	0.086920
26	0.135949	0.181348		27	0.130490	0.174059
27	0.226998	0.272648		28	0.217851	0.261642
28	0.318680	0.364712		29	0.305770	0.349899
29	0.411265	0.457818		30	0.394487	0.439074
30	0.505042	0.552267		31	0.484252	0.529429
31	0.600327	0.648388		32	0.575339	0.621249
32	0.697469	0.746549		33	0.668049	0.714849
33	0.796860	0.847170		34	0.762718	0.810586
34	0.898953	0.950735		35	0.859726	0.908866
35	1.004276	1.057817		36	0.959515	1.010164
36	1.113461	1.169104		37	1.062603	1.115042
37	1.227273	1.285441		38	1.169610	1.224177
38	1.346664	1.407887		39	1.281291	1.338404
39	1.472848	1.537808		40	1.398587	1.458770
40	1.607410	1.677012		41	1.522699	1.586628
41	1.752498	1.827984		42	1.655200	1.723772
42	1.911136	1.994289		43	1.798221	1.872670
43	2.087810	2.181332		44	1.954766	2.036862
44	2.289646	2.397960		45	2.129292	2.221723
45	2.529136	2.660313		46	2.328885	2.436047
46	2.831868	3.003424		47	2.565967	2.695886
47	3.268645	3.533865		48	2.865990	3.036093
				49	3.299397	3.562701
	ERROR =	0.001182			ERROR =	0.001089
	ENTROPY =	5.271972			ENTROPY =	5.330984

N = 48				N = 50		
J	X	Y		J	X	Y
25	0.000000	0.044334		26	0.000000	0.042593
26	0.088727	0.133119		27	0.085238	0.127883
27	0.177688	0.222256		28	0.170683	0.213483
28	0.267121	0.311985		29	0.256546	0.299609
29	0.357273	0.402560		30	0.343046	0.386482
30	0.448405	0.494250		31	0.430411	0.474339
31	0.540798	0.587346		32	0.518887	0.563434
32	0.634759	0.682172		33	0.608740	0.654046
33	0.730630	0.779089		34	0.700265	0.746485
34	0.828799	0.878509		35	0.793793	0.841101
35	0.929711	0.980913		36	0.889699	0.938297
36	1.033889	1.086866		37	0.988420	1.038542
37	1.141959	1.197052		38	1.090468	1.142393
38	1.254681	1.312310		39	1.196459	1.250524
39	1.373002	1.433693		40	1.307144	1.363763
40	1.498127	1.562561		41	1.423458	1.483154
41	1.631638	1.700715		42	1.546598	1.610042
42	1.775672	1.850629		43	1.678130	1.746217
43	1.933243	2.015857		44	1.820177	1.894136
44	2.108823	2.201789		45	1.975733	2.057330
45	2.309518	2.417246		46	2.149243	2.241156
46	2.547783	2.678320		47	2.347771	2.454386
47	2.849138	3.019956		48	2.583709	2.713031
48	3.284204	3.548451		49	2.882442	3.051853
				50	3.314240	3.576627
	ERROR =	0.001134			ERROR =	0.001047
	ENTROPY =	5.301780			ENTROPY =	5.359608

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 51			N = 52		
J	X	Y	J	X	Y
26	-0.041785	0.000000	27	0.000000	0.040984
27	0.041785	0.083570	28	0.082013	0.123043
28	0.125453	0.167335	29	0.164211	0.205379
29	0.209414	0.251494	30	0.246781	0.288182
30	0.293872	0.336250	31	0.329916	0.371650
31	0.379035	0.421820	32	0.413820	0.455989
32	0.465126	0.508433	33	0.498707	0.541425
33	0.552384	0.596336	34	0.584812	0.628199
34	0.641069	0.685803	35	0.672389	0.716579
35	0.731471	0.777139	36	0.761723	0.806867
36	0.823914	0.870690	37	0.853135	0.899402
37	0.918771	0.966852	38	0.946991	0.994580
38	1.016473	1.066093	39	1.043720	1.092860
39	1.117528	1.168963	40	1.143826	1.194792
40	1.222548	1.276133	41	1.247916	1.301040
41	1.332279	1.388425	42	1.356732	1.412425
42	1.447652	1.506880	43	1.471202	1.529980
43	1.569858	1.632837	44	1.592511	1.655042
44	1.700458	1.768079	45	1.722213	1.789384
45	1.841567	1.915055	46	1.862418	1.935451
46	1.996170	2.077285	47	2.016101	2.096751
47	2.168698	2.260112	48	2.187682	2.278613
48	2.366199	2.472285	49	2.384188	2.489762
49	2.601028	2.729772	50	2.617944	2.746127
50	2.898511	3.067251	51	2.914215	3.082303
51	3.328748	3.590245	52	3.342935	3.603567

ERROR = 0.001007 ERROR = 0.000969
ENTROPY = 5.387674 ENTROPY = 5.415203

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N =	53		N =	54	
J	X	Y	J	X	Y
27	-0.040235	0.000000	28	0.000000	0.039491
28	0.040234	0.080469	29	0.079024	0.118556
29	0.120790	0.161112	30	0.158213	0.197869
30	0.201609	0.242106	31	0.237734	0.277599
31	0.282869	0.323633	32	0.317760	0.357922
32	0.364758	0.405884	33	0.398472	0.439022
33	0.447472	0.489060	34	0.480059	0.521097
34	0.531220	0.573381	35	0.562728	0.604359
35	0.616232	0.659083	36	0.646700	0.689042
36	0.702756	0.746430	37	0.732224	0.775405
37	0.791074	0.835719	38	0.819574	0.863742
38	0.881502	0.927286	39	0.909063	0.954384
39	0.974404	1.021522	40	1.001052	1.047720
40	1.070203	1.118884	41	1.095961	1.144202
41	1.169400	1.219917	42	1.194287	1.244373
42	1.272599	1.325281	43	1.296631	1.348889
43	1.380538	1.435794	44	1.403726	1.458564
44	1.494140	1.552485	45	1.516493	1.574422
45	1.614584	1.676684	46	1.636105	1.697789
46	1.743422	1.810160	47	1.764109	1.830430
47	1.882755	1.955349	48	1.902601	1.974772
48	2.035550	2.115751	49	2.054538	2.134304
49	2.206215	2.296678	50	2.224315	2.314327
50	2.401757	2.506836	51	2.418925	2.523524
51	2.634474	2.762113	52	2.650634	2.777745
52	2.929568	3.097023	53	2.944585	3.111426
53	3.356814	3.616605	54	3.370398	3.629370

| | ERROR | = | 0.000934 |
| | ENTROPY | = | 5.442216 |

| | ERROR | = | 0.000900 |
| | ENTROPY | = | 5.468732 |

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N =	55		N =	56	
J	X	Y	J	X	Y
28	-0.038795	0.000000	29	0.000000	0.038104
29	0.038795	0.077590	30	0.076245	0.114386
30	0.116463	0.155336	31	0.152638	0.190890
31	0.194366	0.233396	32	0.229329	0.267769
32	0.272665	0.311934	33	0.306474	0.345179
33	0.351526	0.391118	34	0.384232	0.423285
34	0.431123	0.471128	35	0.462773	0.502261
35	0.511643	0.552158	36	0.542279	0.582297
36	0.593286	0.634414	37	0.622946	0.663595
37	0.676270	0.718127	38	0.704989	0.746383
38	0.760839	0.803552	39	0.788648	0.830913
39	0.847265	0.890979	40	0.874191	0.917470
40	0.935858	0.980737	41	0.961926	1.006382
41	1.026974	1.073210	42	1.052205	1.098028
42	1.121030	1.168849	43	1.145443	1.192857
43	1.218521	1.268192	44	1.242131	1.291405
44	1.320042	1.371893	45	1.342863	1.394321
45	1.426327	1.480761	46	1.448366	1.502411
46	1.538289	1.595817	47	1.559553	1.616694
47	1.657099	1.718382	48	1.677590	1.738486
48	1.784299	1.850216	49	1.804013	1.869539
49	1.921977	1.993738	50	1.940904	2.012269
50	2.073084	2.152429	51	2.091207	2.170146
51	2.242003	2.331577	52	2.259295	2.348444
52	2.435709	2.539841	53	2.452124	2.555804
53	2.666439	2.793037	54	2.681904	2.808004
54	2.959280	3.125523	55	2.973665	3.139327
55	3.383698	3.641873	56	3.396725	3.654124

ERROR	=	0.000868
ENTROPY	=	5.494769

ERROR	=	0.000838
ENTROPY	=	5.520344

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N =	57		N =	58	
J	X	Y	J	X	Y
29	-0.037455	0.000000	30	0.000000	0.036811
30	0.037455	0.074910	31	0.073655	0.110499
31	0.112435	0.149960	32	0.147443	0.184388
32	0.187627	0.225293	33	0.221501	0.258614
33	0.263174	0.301055	34	0.295966	0.333318
34	0.339226	0.377398	35	0.370983	0.408647
35	0.415939	0.454480	36	0.446703	0.484758
36	0.493477	0.532474	37	0.523288	0.561817
37	0.572019	0.611564	38	0.600911	0.640004
38	0.651756	0.691949	39	0.679761	0.719519
39	0.732902	0.773854	40	0.760049	0.800579
40	0.815691	0.857527	41	0.842006	0.883433
41	0.900390	0.943252	42	0.925896	0.968359
42	0.987302	1.031352	43	1.012020	1.055681
43	1.076779	1.122205	44	1.100726	1.145772
44	1.169231	1.216257	45	1.192423	1.239075
45	1.265148	1.314039	46	1.287597	1.336120
46	1.365119	1.416199	47	1.386836	1.437552
47	1.469870	1.523541	48	1.490862	1.544171
48	1.580309	1.637077	49	1.600579	1.656986
49	1.697599	1.758121	50	1.717147	1.777307
50	1.823270	1.888420	51	1.842092	1.906876
51	1.959401	2.030382	52	1.977486	2.048095
52	2.108926	2.187470	53	2.126256	2.204417
53	2.276207	2.364944	54	2.292755	2.381092
54	2.468185	2.571426	55	2.483906	2.586720
55	2.697042	2.822658	56	2.711865	2.837011
56	2.987753	3.152848	57	3.001555	3.166099
57	3.409491	3.666133	58	3.422003	3.677908
	ERROR =	0.000809		ERROR =	0.000782
	ENTROPY =	5.545472		ENTROPY =	5.570170

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 59		
J	X	Y
30	-0.036205	0.000000
31	0.036204	0.072409
32	0.108677	0.144945
33	0.181340	0.217736
34	0.254325	0.290914
35	0.327764	0.364614
36	0.401798	0.438982
37	0.476574	0.514167
38	0.552251	0.590335
39	0.628998	0.667661
40	0.707002	0.746343
41	0.786469	0.826595
42	0.867629	0.908663
43	0.950744	0.992824
44	1.036111	1.079398
45	1.124077	1.168756
46	1.215047	1.261339
47	1.309506	1.357674
48	1.408038	1.458403
49	1.511363	1.564324
50	1.620383	1.676442
51	1.736253	1.796064
52	1.860495	1.924926
53	1.995175	2.065424
54	2.143214	2.221004
55	2.308953	2.396902
56	2.499301	2.601700
57	2.726387	2.851074
58	3.015081	3.179088
59	3.434273	3.689458

ERROR   = 0.000756
ENTROPY = 5.594452

N = 60		
J	X	Y
31	0.000000	0.035602
32	0.071235	0.106868
33	0.142591	0.178315
34	0.214191	0.250066
35	0.286158	0.322250
36	0.358624	0.394997
37	0.431723	0.468449
38	0.505601	0.542753
39	0.580411	0.618069
40	0.656321	0.694574
41	0.733516	0.772458
42	0.812197	0.851936
43	0.892593	0.933251
44	0.974964	1.016676
45	1.059603	1.102530
46	1.146857	1.191183
47	1.237127	1.283072
48	1.330897	1.378722
49	1.428748	1.478773
50	1.531396	1.584019
51	1.639741	1.695464
52	1.754936	1.814408
53	1.878496	1.942585
54	2.012484	2.082384
55	2.159813	2.237243
56	2.324814	2.412386
57	2.514381	2.616377
58	2.740618	2.864858
59	3.028342	3.191826
60	3.446309	3.700791

ERROR   = 0.000732
ENTROPY = 5.618331

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

J	X	Y	J	X	Y
	N = 61			N = 62	
31	-0.035035	0.000000	32	0.000000	0.034471
32	0.035035	0.070070	33	0.068970	0.103468
33	0.105162	0.140254	34	0.138049	0.172630
34	0.175462	0.210670	35	0.207349	0.242068
35	0.246053	0.281436	36	0.276983	0.311897
36	0.317056	0.352675	37	0.347067	0.382238
37	0.388595	0.424516	38	0.417726	0.453214
38	0.460805	0.497094	39	0.489087	0.524960
39	0.533826	0.570557	40	0.561289	0.597618
40	0.607809	0.645061	41	0.634481	0.671344
41	0.682919	0.720778	42	0.708826	0.746307
42	0.759338	0.797898	43	0.784501	0.822695
43	0.837266	0.876634	44	0.861707	0.900718
44	0.916929	0.957225	45	0.940666	0.980613
45	0.998584	1.039944	46	1.021633	1.062652
46	1.082525	1.125105	47	1.104900	1.147147
47	1.169092	1.213078	48	1.190806	1.234465
48	1.258688	1.304298	49	1.279751	1.325038
49	1.351792	1.399287	50	1.372213	1.419388
50	1.448985	1.498683	51	1.468769	1.518150
51	1.550979	1.603276	52	1.570131	1.622112
52	1.658672	1.714068	53	1.677192	1.732272
53	1.773212	1.832356	54	1.791098	1.849924
54	1.896112	1.959868	55	1.913358	1.976792
55	2.029429	2.098989	56	2.046023	2.115254
56	2.176068	2.253147	57	2.191992	2.268731
57	2.340352	2.427557	58	2.355579	2.442426
58	2.529159	2.630762	59	2.543647	2.644867
59	2.754568	2.878375	60	2.768249	2.891632
60	3.041348	3.204322	61	3.054108	3.216583
61	3.458118	3.711915	62	3.469710	3.722837
	ERROR = 0.000708			ERROR = 0.000686	
	ENTROPY = 5.641821			ENTROPY = 5.664934	

TABLE 1
MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 63			N = 64		
J	X	Y	J	X	Y
32	-0.033939	0.000000	33	0.000000	0.033409
33	0.033938	0.067877	34	0.066844	0.100278
34	0.101868	0.135859	35	0.133787	0.167297
35	0.169954	0.204050	36	0.200932	0.234567
36	0.238305	0.272559	37	0.268380	0.302193
37	0.307029	0.341498	38	0.336238	0.370283
38	0.376240	0.410982	39	0.404616	0.438950
39	0.446058	0.481134	40	0.473632	0.508314
40	0.516609	0.552084	41	0.543408	0.578503
41	0.588029	0.623973	42	0.614079	0.649655
42	0.660464	0.696954	43	0.685789	0.721922
43	0.734074	0.771194	44	0.758695	0.795468
44	0.809036	0.846879	45	0.832972	0.870476
45	0.885548	0.924217	46	0.908816	0.947155
46	0.963830	1.003442	47	0.986446	1.025736
47	1.044134	1.084826	48	1.066112	1.106488
48	1.126752	1.168678	49	1.148104	1.189720
49	1.212021	1.255363	50	1.232757	1.275794
50	1.300338	1.345313	51	1.320468	1.365141
51	1.392179	1.439046	52	1.411709	1.458276
52	1.488120	1.537194	53	1.507054	1.555831
53	1.588869	1.640545	54	1.607210	1.658589
54	1.695318	1.750092	55	1.713065	1.767542
55	1.808609	1.867126	56	1.825759	1.883977
56	1.930247	1.993368	57	1.946794	2.009611
57	2.062279	2.131190	58	2.078211	2.146810
58	2.207598	2.284005	59	2.222896	2.298981
59	2.370505	2.457006	60	2.385143	2.471305
60	2.557853	2.658701	61	2.571789	2.672274
61	2.781670	2.904640	62	2.794840	2.917407
62	3.066629	3.228619	63	3.078922	3.240437
63	3.481091	3.733563	64	3.492269	3.744101
	ERROR =	0.000665		ERROR =	0.000644
	ENTROPY =	5.687683		ENTROPY =	5.710078

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 65			N = 66		
J	X	Y	J	X	Y
33	-0.032909	0.000000	34	0.000000	0.032411
34	0.032909	0.065817	35	0.064845	0.097279
35	0.098774	0.131730	36	0.129782	0.162284
36	0.164782	0.197834	37	0.194901	0.227518
37	0.231031	0.264228	38	0.260298	0.293077
38	0.297620	0.331012	39	0.326068	0.359058
39	0.364652	0.398292	40	0.392312	0.425565
40	0.432235	0.466179	41	0.459135	0.492705
41	0.500484	0.534789	42	0.526650	0.560594
42	0.569520	0.604250	43	0.594975	0.629356
43	0.639473	0.674696	44	0.664240	0.699124
44	0.710486	0.746276	45	0.734585	0.770045
45	0.782716	0.819155	46	0.806164	0.842282
46	0.856334	0.893514	47	0.879149	0.916015
47	0.931536	0.969557	48	0.953731	0.991447
48	1.008537	1.047518	49	1.030127	1.068808
49	1.087589	1.127660	50	1.108585	1.148362
50	1.168977	1.210293	51	1.189389	1.230416
51	1.253035	1.295777	52	1.272873	1.315329
52	1.340159	1.384540	53	1.359429	1.403528
53	1.430819	1.477097	54	1.449526	1.495525
54	1.525587	1.574077	55	1.543735	1.591946
55	1.625168	1.676260	56	1.642759	1.693571
56	1.730448	1.784636	57	1.747480	1.801388
57	1.842563	1.900490	58	1.859032	1.916676
58	1.963011	2.025532	59	1.978910	2.041144
59	2.093829	2.162126	60	2.109146	2.177148
60	2.237898	2.313670	61	2.252614	2.328081
61	2.399502	2.485334	62	2.413592	2.499102
62	2.585464	2.685595	63	2.598887	2.698672
63	2.807768	2.929941	64	2.820462	2.942251
64	3.090993	3.252044	65	3.102849	3.263448
65	3.503250	3.754457	66	3.514042	3.764636

ERROR = 0.000625	ERROR = 0.000606
ENTROPY = 5.732130	ENTROPY = 5.753849

TABLE I

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N =	67		N =	68	
J	X	Y	J	X	Y
34	-0.031940	0.000000	35	0.000000	0.031471
35	0.031940	0.063879	36	0.062963	0.094455
36	0.095862	0.127846	37	0.126009	0.157563
37	0.159916	0.191987	38	0.189223	0.220882
38	0.224190	0.256392	39	0.252690	0.284497
39	0.288774	0.321155	40	0.316498	0.348499
40	0.353762	0.386369	41	0.380740	0.412980
41	0.419253	0.452136	42	0.445509	0.478039
42	0.485349	0.518562	43	0.510909	0.543779
43	0.552160	0.585759	44	0.577046	0.610312
44	0.619804	0.653850	45	0.644036	0.677759
45	0.688408	0.722966	46	0.712004	0.746249
46	0.758110	0.793254	47	0.781088	0.815927
47	0.829064	0.864874	48	0.851439	0.886951
48	0.901438	0.938003	49	0.923225	0.959499
49	0.975424	1.012845	50	0.996635	1.033771
50	1.051236	1.089627	51	1.071883	1.109995
51	1.129120	1.168613	52	1.149213	1.188431
52	1.209360	1.250108	53	1.228907	1.269384
53	1.292288	1.334468	54	1.311296	1.353209
54	1.378294	1.422119	55	1.396770	1.440330
55	1.467846	1.513573	56	1.485794	1.531257
56	1.561513	1.609453	57	1.578934	1.626612
57	1.659995	1.710537	58	1.676891	1.727170
58	1.764174	1.817810	59	1.780542	1.833913
59	1.875179	1.932548	60	1.891015	1.948117
60	1.994502	2.056456	61	2.009799	2.071481
61	2.124172	2.191887	62	2.138917	2.206352
62	2.267056	2.342225	63	2.281231	2.356110
63	2.427422	2.512619	64	2.441001	2.525893
64	2.612067	2.711515	65	2.625011	2.724130
65	2.832929	2.954343	66	2.845178	2.966225
66	3.114499	3.274654	67	3.125948	3.285670
67	3.524649	3.774644	68	3.535079	3.784487

	ERROR =	0.000589		ERROR =	0.000572
	ENTROPY =	5.775247		ENTROPY =	5.796331

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 69		
J	X	Y
35	-0.031026	0.000000
36	0.031026	0.062052
37	0.093118	0.124184
38	0.155330	0.186476
39	0.217743	0.249010
40	0.280440	0.311871
41	0.343508	0.375145
42	0.407034	0.438924
43	0.471114	0.503304
44	0.535845	0.568387
45	0.601334	0.634282
46	0.667696	0.701109
47	0.735053	0.768997
48	0.803542	0.838087
49	0.873312	0.908537
50	0.944530	0.980523
51	1.017384	1.054245
52	1.092086	1.129928
53	1.168880	1.207832
54	1.248046	1.288260
55	1.329914	1.371567
56	1.414871	1.458174
57	1.503382	1.548590
58	1.596012	1.643434
59	1.693458	1.743481
60	1.796596	1.849710
61	1.906552	1.963393
62	2.024810	2.086227
63	2.153390	2.220554
64	2.295149	2.369745
65	2.454338	2.538931
66	2.637728	2.736526
67	2.857215	2.977904
68	3.137203	3.296502
69	3.545336	3.794170

ERROR   = 0.000555
ENTROPY = 5.817111

N = 70		
J	X	Y
36	0.000000	0.030584
37	0.061187	0.091789
38	0.122450	0.153110
39	0.183867	0.214623
40	0.245516	0.276408
41	0.307478	0.338547
42	0.369836	0.401125
43	0.432678	0.464231
44	0.496095	0.527959
45	0.560185	0.592411
46	0.625052	0.657693
47	0.690809	0.723924
48	0.757577	0.791230
49	0.825492	0.859754
50	0.894702	0.929650
51	0.965372	1.001094
52	1.037689	1.074284
53	1.111864	1.149444
54	1.188138	1.226833
55	1.266793	1.306753
56	1.348155	1.389557
57	1.432611	1.475665
58	1.520625	1.565584
59	1.612758	1.659933
60	1.709708	1.759483
61	1.812347	1.865211
62	1.921799	1.978387
63	2.039546	2.100704
64	2.167602	2.234500
65	2.308819	2.383139
66	2.467440	2.551742
67	2.650225	2.748708
68	2.869047	2.989386
69	3.148270	3.307154
70	3.555426	3.803697

ERROR   = 0.000540
ENTROPY = 5.837596

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 71		
J	X	Y
36	-0.030163	0.000000
37	0.030163	0.060326
38	0.090526	0.120726
39	0.151000	0.181273
40	0.211658	0.242043
41	0.272577	0.303111
42	0.333835	0.364559
43	0.395515	0.426470
44	0.457700	0.488930
45	0.520481	0.552033
46	0.583955	0.615877
47	0.648223	0.680569
48	0.713397	0.746225
49	0.779599	0.812972
50	0.846960	0.880948
51	0.915629	0.950309
52	0.985769	1.021229
53	1.057567	1.093904
54	1.131231	1.168558
55	1.207004	1.245449
56	1.285162	1.324876
57	1.366034	1.407192
58	1.450004	1.492816
59	1.537534	1.582252
60	1.629185	1.676119
61	1.725652	1.775185
62	1.827806	1.880426
63	1.936767	1.993109
64	2.054015	2.114922
65	2.181560	2.248199
66	2.322249	2.396299
67	2.480316	2.564333
68	2.662509	2.760685
69	2.880681	3.000678
70	3.159156	3.317633
71	3.565354	3.813074
ERROR =	0.000525	
ENTROPY =	5.857794	

N = 72		
J	X	Y
37	0.000000	0.029745
38	0.059508	0.089271
39	0.119086	0.148902
40	0.178806	0.208710
41	0.238739	0.268768
42	0.298960	0.329152
43	0.359544	0.389937
44	0.420573	0.451208
45	0.482128	0.513048
46	0.544298	0.575549
47	0.607179	0.638809
48	0.670871	0.702933
49	0.735484	0.768035
50	0.801138	0.834241
51	0.867965	0.901689
52	0.936111	0.970533
53	1.005740	1.040946
54	1.077034	1.113123
55	1.150205	1.187286
56	1.225490	1.263693
57	1.303168	1.342642
58	1.383564	1.424485
59	1.467061	1.509638
60	1.554121	1.598605
61	1.645304	1.692003
62	1.741301	1.790599
63	1.842982	1.895365
64	1.951465	2.007566
65	2.068227	2.128888
66	2.195274	2.261659
67	2.335446	2.409233
68	2.492972	2.576711
69	2.674586	2.772462
70	2.892123	3.011784
71	3.169865	3.327945
72	3.575124	3.822304
ERROR =	0.000511	
ENTROPY =	5.877713	

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N =	73		N =	74	
J	X	Y	J	X	Y
37	-0.029347	0.000000	38	0.000000	0.028951
38	0.029347	0.058694	39	0.057919	0.086887
39	0.088075	0.117456	40	0.115903	0.144919
40	0.146905	0.176353	41	0.174017	0.203115
41	0.205904	0.235455	42	0.232328	0.261541
42	0.265144	0.294833	43	0.290904	0.320266
43	0.324696	0.354559	44	0.349814	0.379362
44	0.384634	0.414710	45	0.409133	0.438903
45	0.445037	0.475365	46	0.468935	0.498967
46	0.505987	0.536609	47	0.529302	0.559637
47	0.567570	0.598531	48	0.590320	0.621002
48	0.629880	0.661229	49	0.652080	0.683157
49	0.693017	0.724805	50	0.714681	0.746204
50	0.757088	0.789372	51	0.778230	0.810256
51	0.822214	0.855057	52	0.842846	0.875436
52	0.888525	0.921994	53	0.908658	0.941880
53	0.956166	0.990338	54	0.975810	1.009740
54	1.025299	1.060260	55	1.044463	1.079186
55	1.096107	1.131954	56	1.114799	1.150413
56	1.168798	1.205642	57	1.187026	1.223640
57	1.243611	1.281580	58	1.261381	1.299122
58	1.320823	1.360065	59	1.338139	1.377156
59	1.400756	1.441447	60	1.417624	1.458091
60	1.483795	1.526143	61	1.500216	1.542342
61	1.570398	1.614654	62	1.586375	1.630409
62	1.661125	1.707595	63	1.676658	1.722906
63	1.756664	1.805733	64	1.771752	1.820597
64	1.857885	1.910037	65	1.872523	1.924450
65	1.965902	2.021768	66	1.980087	2.035724
66	2.082190	2.142611	67	2.095911	2.156099
67	2.208750	2.274888	68	2.221996	2.287894
68	2.348418	2.421948	69	2.361172	2.434451
69	2.505415	2.588882	70	2.517652	2.600853
70	2.686464	2.784046	71	2.698148	2.795442
71	2.903379	3.022712	72	2.914454	3.033465
72	3.180402	3.338093	73	3.190774	3.348083
73	3.584743	3.831392	74	3.594213	3.840343
	ERROR =	0.000497		ERROR =	0.000484
	ENTROPY =	5.897360		ENTROPY =	5.916743

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 75			N = 76		
J	X	Y	J	X	Y
38	-0.028574	0.000000	39	0.000000	0.028199
39	0.028574	0.057148	40	0.056413	0.084627
40	0.085753	0.114359	41	0.112885	0.141144
41	0.143026	0.171694	42	0.169479	0.197813
42	0.200456	0.229219	43	0.226253	0.254694
43	0.258108	0.286997	44	0.283272	0.311851
44	0.316047	0.345096	45	0.340600	0.369350
45	0.374342	0.403587	46	0.398304	0.427258
46	0.433064	0.462541	47	0.456454	0.485649
47	0.492289	0.522037	48	0.515123	0.544597
48	0.552096	0.582155	49	0.574389	0.604182
49	0.612569	0.642982	50	0.634337	0.664491
50	0.673798	0.704614	51	0.695054	0.725617
51	0.735882	0.767151	52	0.756639	0.787661
52	0.798927	0.830704	53	0.819197	0.850732
53	0.863050	0.895396	54	0.882842	0.914952
54	0.928379	0.961362	55	0.947704	0.980455
55	0.995057	1.028753	56	1.013924	1.047392
56	1.063246	1.097739	57	1.081662	1.115931
57	1.133125	1.168511	58	1.151097	1.186264
58	1.204901	1.241291	59	1.222436	1.258609
59	1.278811	1.316331	60	1.295914	1.333219
60	1.355129	1.393928	61	1.371804	1.410390
61	1.434178	1.474427	62	1.450428	1.490466
62	1.516336	1.558245	63	1.532165	1.573863
63	1.602063	1.645880	64	1.617470	1.661077
64	1.691912	1.737945	65	1.706898	1.752720
65	1.786572	1.835200	66	1.801135	1.849550
66	1.886907	1.938613	67	1.901042	1.952534
67	1.994027	2.049440	68	2.007730	2.062925
68	2.109399	2.169358	69	2.122661	2.182397
69	2.235020	2.300682	70	2.247829	2.313261
70	2.373715	2.446748	71	2.386053	2.458846
71	2.529689	2.612631	72	2.541533	2.624220
72	2.709644	2.806657	73	2.720957	2.817695
73	2.925354	3.044050	74	2.936083	3.054471
74	3.200985	3.357920	75	3.211039	3.367607
75	3.603540	3.849160	76	3.612727	3.857846

ERROR = 0.000471	ERROR = 0.000459
ENTROPY = 5.935869	ENTROPY = 5.954745

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 77			N = 78		
J	X	Y	J	X	Y
39	-0.027841	0.000000	40	0.000000	0.027484
40	0.027841	0.055681	41	0.054983	0.082481
41	0.083551	0.111420	42	0.110021	0.137561
42	0.139348	0.167275	43	0.165171	0.192781
43	0.195290	0.223305	44	0.220489	0.248197
44	0.251437	0.279568	45	0.276033	0.303869
45	0.307849	0.336129	46	0.331862	0.359856
46	0.364590	0.393050	47	0.388039	0.416222
47	0.421725	0.450400	48	0.444627	0.473032
48	0.479323	0.508247	49	0.501694	0.530356
49	0.537457	0.566667	50	0.559311	0.588267
50	0.596203	0.625739	51	0.617555	0.646843
51	0.655643	0.685548	52	0.676506	0.706168
52	0.715866	0.746185	53	0.736251	0.766334
53	0.776969	0.807752	54	0.796887	0.827439
54	0.839054	0.870357	55	0.858516	0.889592
55	0.902238	0.934120	56	0.921252	0.952912
56	0.966647	0.999175	57	0.985222	1.017533
57	1.032423	1.065671	58	1.050567	1.083601
58	1.099723	1.133776	59	1.117443	1.151286
59	1.168728	1.203681	60	1.186030	1.220775
60	1.239643	1.275604	61	1.256532	1.292288
61	1.312700	1.349797	62	1.329181	1.366075
62	1.388175	1.426553	63	1.404251	1.442428
63	1.466386	1.506218	64	1.482060	1.521692
64	1.547711	1.589204	65	1.562985	1.604278
65	1.632606	1.676008	66	1.647480	1.690682
66	1.721624	1.767239	67	1.736097	1.781512
67	1.815448	1.863656	68	1.829518	1.877524
68	1.914939	1.966221	69	1.928603	1.979681
69	2.021204	2.076186	70	2.034455	2.089230
70	2.135704	2.195222	71	2.148535	2.207839
71	2.260429	2.325635	72	2.272826	2.337812
72	2.398193	2.470750	73	2.410140	2.482467
73	2.553188	2.635626	74	2.564661	2.646855
74	2.732094	2.828562	75	2.743059	2.839262
75	2.946648	3.064734	76	2.957052	3.074841
76	3.220942	3.377150	77	3.230696	3.386552
77	3.621778	3.866407	78	3.630698	3.874844
	ERROR =	0.000447		ERROR =	0.000436
	ENTROPY =	5.973376		ENTROPY =	5.991770

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N =	79		N =	80	
J	X	Y	J	X	Y
40	-0.027144	0.000000	41	0.000000	0.026805
41	0.027144	0.054288	42	0.053624	0.080442
42	0.081459	0.108630	43	0.107299	0.134156
43	0.135854	0.163078	44	0.161078	0.187999
44	0.190384	0.217689	45	0.215012	0.242025
45	0.245103	0.272517	46	0.269156	0.296287
46	0.300068	0.327619	47	0.323564	0.350842
47	0.355337	0.383055	48	0.378294	0.405746
48	0.410970	0.438886	49	0.433404	0.461062
49	0.467031	0.495177	50	0.488957	0.516852
50	0.523586	0.551996	51	0.545018	0.573184
51	0.580705	0.609415	52	0.601656	0.630128
52	0.638463	0.667512	53	0.658946	0.687763
53	0.696941	0.726370	54	0.716966	0.746168
54	0.756225	0.786079	55	0.775802	0.805436
55	0.816408	0.846738	56	0.835548	0.865661
56	0.877595	0.908453	57	0.896307	0.926952
57	0.939898	0.971344	58	0.958189	0.989426
58	1.003443	1.035542	59	1.021321	1.053215
59	1.068369	1.101196	60	1.085841	1.118466
60	1.134834	1.168471	61	1.151905	1.185344
61	1.203014	1.237558	62	1.219691	1.254038
62	1.273114	1.308671	63	1.289400	1.324763
63	1.345367	1.382062	64	1.361266	1.397769
64	1.420042	1.458023	65	1.435558	1.473347
65	1.497459	1.536896	66	1.512594	1.551840
66	1.577994	1.619093	67	1.592748	1.633657
67	1.662100	1.705107	68	1.676473	1.719290
68	1.750326	1.795545	69	1.764318	1.809347
69	1.843354	1.891163	70	1.856963	1.904579
70	1.942042	1.992920	71	1.955262	2.005946
71	2.047491	2.102062	72	2.060318	2.114690
72	2.161159	2.220255	73	2.173583	2.232475
73	2.285026	2.349797	74	2.297036	2.361596
74	2.421900	2.494002	75	2.433478	2.505360
75	2.575957	2.657912	76	2.587081	2.668802
76	2.753857	2.849801	77	2.764492	2.860183
77	2.967300	3.084799	78	2.977397	3.094610
78	3.240308	3.395816	79	3.249779	3.404948
79	3.639489	3.883161	80	3.648155	3.891362

ERROR =	0.000425	
ENTROPY =	6.009932	

ERROR =	0.000415
ENTROPY =	6.027868

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 81			N = 82		
J	X	Y	J	X	Y
41	-0.026482	0.000000	42	0.000000	0.026159
42	0.026481	0.052963	43	0.052330	0.078501
43	0.079469	0.105975	44	0.104708	0.130915
44	0.132531	0.159087	45	0.157182	0.183450
45	0.185718	0.212349	46	0.209801	0.236153
46	0.239081	0.265813	47	0.262615	0.289076
47	0.292672	0.319531	48	0.315673	0.342271
48	0.346545	0.373559	49	0.369030	0.395790
49	0.400755	0.427952	50	0.422740	0.449690
50	0.455361	0.482771	51	0.476859	0.504029
51	0.510424	0.538077	52	0.531449	0.558869
52	0.566008	0.593938	53	0.586572	0.614275
53	0.622181	0.650424	54	0.642296	0.670316
54	0.679017	0.707610	55	0.698693	0.727069
55	0.736594	0.765578	56	0.755841	0.784613
56	0.794998	0.824417	57	0.813825	0.843037
57	0.854320	0.884223	58	0.872736	0.902436
58	0.914663	0.945102	59	0.932676	0.962916
59	0.976137	1.007172	60	0.993754	1.024593
60	1.038868	1.070564	61	1.056096	1.087598
61	1.102993	1.135423	62	1.119837	1.152076
62	1.168669	1.201914	63	1.185134	1.218192
63	1.236070	1.270226	64	1.252162	1.286132
64	1.305400	1.340574	65	1.321122	1.356111
65	1.376889	1.413205	66	1.392244	1.428377
66	1.450808	1.488410	67	1.465798	1.503219
67	1.527471	1.566532	68	1.542099	1.580979
68	1.607255	1.647977	69	1.621521	1.662063
69	1.690609	1.733240	70	1.704513	1.746963
70	1.778081	1.822923	71	1.791622	1.836281
71	1.870351	1.917779	72	1.883525	1.930769
72	1.968271	2.018764	73	1.981075	2.031381
73	2.072942	2.127120	74	2.085369	2.139356
74	2.185813	2.244506	75	2.197854	2.256352
75	2.308860	2.373214	76	2.320504	2.384656
76	2.444880	2.516546	77	2.456110	2.527564
77	2.598037	2.679529	78	2.608831	2.690098
78	2.774970	2.870412	79	2.785295	2.880492
79	2.987346	3.104280	80	2.997152	3.113811
80	3.259115	3.413950	81	3.268318	3.422826
81	3.656700	3.899450	82	3.665126	3.907427
	ERROR =	0.000405		ERROR =	0.000395
	ENTROPY =	6.045584		ENTROPY =	6.063084

28

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 83			N = 84		
J	X	Y	J	X	Y
42	-0.025851	0.000000	43	0.000000	0.025543
43	0.025850	0.051701	44	0.051098	0.076652
44	0.077574	0.103448	45	0.102240	0.127828
45	0.129368	0.155287	46	0.153472	0.179115
46	0.181277	0.207266	47	0.204838	0.230560
47	0.233350	0.259433	48	0.256385	0.282210
48	0.285634	0.311836	49	0.308161	0.334111
49	0.338181	0.364525	50	0.360213	0.386315
50	0.391040	0.417555	51	0.412593	0.438871
51	0.444267	0.470979	52	0.465353	0.491835
52	0.497917	0.524854	53	0.518549	0.545263
53	0.552049	0.579243	54	0.572239	0.599215
54	0.606726	0.634209	55	0.626485	0.653755
55	0.662015	0.689821	56	0.681353	0.708951
56	0.717987	0.746153	57	0.736914	0.764876
57	0.774720	0.803287	58	0.793244	0.821611
58	0.832297	0.861308	59	0.850426	0.879241
59	0.890810	0.920312	60	0.908551	0.937862
60	0.950358	0.980404	61	0.967719	0.997577
61	1.011052	1.041700	62	1.028039	1.058502
62	1.073014	1.104329	63	1.089634	1.120766
63	1.136383	1.168437	64	1.152640	1.184513
64	1.201311	1.234186	65	1.217210	1.249907
65	1.267976	1.301765	66	1.283519	1.317132
66	1.336575	1.371385	67	1.351768	1.386403
67	1.407340	1.443295	68	1.422184	1.457966
68	1.480539	1.517783	69	1.495037	1.532108
69	1.556486	1.595189	70	1.570638	1.609169
70	1.635554	1.675920	71	1.649362	1.689555
71	1.718192	1.760465	72	1.731654	1.773754
72	1.804946	1.849427	73	1.818061	1.862368
73	1.896492	1.943556	74	1.909256	1.956145
74	1.993679	2.043802	75	2.006089	2.056034
75	2.097604	2.151406	76	2.109653	2.163273
76	2.209712	2.268019	77	2.221392	2.279512
77	2.331973	2.395926	78	2.343271	2.407031
78	2.467173	2.538420	79	2.478075	2.549119
79	2.619467	2.700513	80	2.629948	2.710778
80	2.795471	2.890428	81	2.805501	2.900224
81	3.006818	3.123208	82	3.016349	3.132474
82	3.277393	3.431578	83	3.286343	3.440212
83	3.673438	3.915297	84	3.681637	3.923061

ERROR	=	0.000386	ERROR	=	0.000377
ENTROPY	=	6.080375	ENTROPY	=	6.097461

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 85		
J	X	Y
43	-0.025249	0.000000
44	0.025249	0.050498
45	0.075768	0.101038
46	0.126352	0.151665
47	0.177043	0.202422
48	0.227887	0.253353
49	0.278928	0.304504
50	0.330213	0.355922
51	0.381789	0.407656
52	0.433706	0.459756
53	0.486016	0.512276
54	0.538773	0.565270
55	0.592035	0.618800
56	0.645864	0.672927
57	0.700323	0.727720
58	0.755485	0.783250
59	0.811424	0.839598
60	0.868224	0.896849
61	0.925973	0.955097
62	0.984771	1.014446
63	1.044728	1.075010
64	1.105964	1.136919
65	1.168617	1.200315
66	1.232838	1.265361
67	1.298802	1.332243
68	1.366708	1.401173
69	1.436785	1.472397
70	1.509299	1.546201
71	1.584564	1.622926
72	1.662950	1.702974
73	1.744905	1.786836
74	1.830972	1.875109
75	1.921825	1.968541
76	2.018311	2.068081
77	2.121522	2.174963
78	2.232899	2.290835
79	2.354405	2.417974
80	2.488818	2.559663
81	2.640281	2.720898
82	2.815390	2.909882
83	3.025747	3.141613
84	3.295171	3.448728
85	3.689726	3.930724
ERROR =	0.000368	
ENTROPY =	6.114346	

N = 86		
J	X	Y
44	0.000000	0.024956
45	0.049922	0.074888
46	0.099885	0.124883
47	0.149932	0.174982
48	0.200104	0.225227
49	0.250445	0.275663
50	0.300999	0.326334
51	0.351810	0.377286
52	0.402926	0.428566
53	0.454396	0.480225
54	0.506270	0.532315
55	0.558603	0.584891
56	0.611451	0.638011
57	0.664875	0.691738
58	0.718939	0.746140
59	0.773714	0.801287
60	0.829274	0.857260
61	0.885701	0.914142
62	0.943085	0.972028
63	1.001524	1.031020
64	1.061127	1.091234
65	1.122015	1.152796
66	1.184323	1.215850
67	1.248204	1.280558
68	1.313832	1.347105
69	1.381404	1.415703
70	1.451149	1.486596
71	1.523333	1.560071
72	1.598268	1.636466
73	1.676326	1.716185
74	1.757951	1.799716
75	1.843686	1.887656
76	1.934204	1.980751
77	2.030350	2.079949
78	2.133215	2.186481
79	2.244237	2.301993
80	2.365377	2.428760
81	2.499409	2.570057
82	2.650467	2.730877
83	2.825142	2.919407
84	3.035017	3.150627
85	3.303879	3.457131
86	3.697709	3.938287
ERROR =	0.000359	
ENTROPY =	6.131036	

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 87			N = 88		
J	X	Y	J	X	Y
44	-0.024675	0.000000	45	0.000000	0.024395
45	0.024674	0.049349	46	0.048799	0.073203
46	0.074044	0.098738	47	0.097637	0.122070
47	0.123473	0.148208	48	0.146552	0.171035
48	0.173003	0.197799	49	0.195585	0.220136
49	0.222675	0.247552	50	0.244775	0.269415
50	0.272531	0.297511	51	0.294164	0.318913
51	0.322615	0.347718	52	0.343793	0.368673
52	0.372969	0.398220	53	0.393706	0.418739
53	0.423641	0.449062	54	0.443948	0.469158
54	0.474678	0.500294	55	0.494567	0.519977
55	0.526131	0.551968	56	0.545612	0.571248
56	0.578053	0.604138	57	0.597136	0.623024
57	0.630499	0.656861	58	0.649194	0.675364
58	0.683531	0.710201	59	0.701845	0.728327
59	0.737212	0.764223	60	0.755154	0.781980
60	0.791611	0.818999	61	0.809188	0.836395
61	0.846803	0.874606	62	0.864022	0.891648
62	0.902868	0.931130	63	0.919736	0.947824
63	0.959897	0.988664	64	0.976419	1.005015
64	1.017987	1.047310	65	1.034169	1.063323
65	1.077246	1.107182	66	1.093093	1.122862
66	1.137794	1.168406	67	1.153310	1.183758
67	1.199767	1.231127	68	1.214956	1.246155
68	1.263317	1.295506	69	1.278183	1.310211
69	1.328616	1.361726	70	1.343162	1.376112
70	1.395862	1.429999	71	1.410090	1.444068
71	1.465284	1.500569	72	1.479196	1.514323
72	1.537145	1.573722	73	1.550742	1.587162
73	1.611759	1.649796	74	1.625042	1.662921
74	1.689494	1.729193	75	1.702462	1.742003
75	1.770797	1.812400	76	1.783449	1.824894
76	1.856207	1.900014	77	1.868542	1.912189
77	1.946397	1.992780	78	1.958410	2.004631
78	2.042211	2.091642	79	2.053898	2.103166
79	2.144737	2.197832	80	2.156092	2.209019
80	2.255412	2.312992	81	2.266427	2.323834
81	2.376192	2.439392	82	2.386855	2.449876
82	2.509849	2.580306	83	2.520145	2.590413
83	2.660511	2.740717	84	2.670418	2.750422
84	2.834759	2.928802	85	2.844246	2.938070
85	3.044161	3.159520	86	3.053183	3.168295
86	3.312472	3.465423	87	3.320951	3.473608
87	3.705588	3.945753	88	3.713365	3.953123

| | ERROR   = | 0.000351 | | ERROR   = | 0.000344 |
| | ENTROPY = | 6.147535 | | ENTROPY = | 6.163848 |

31

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N =	89		N =	90	
J	X	Y	J	X	Y
45	-0.024126	0.000000	46	0.000000	0.023858
46	0.024126	0.048252	47	0.047725	0.071593
47	0.072396	0.096541	48	0.095487	0.119382
48	0.120723	0.144905	49	0.143322	0.167262
49	0.169144	0.193383	50	0.191266	0.215270
50	0.217697	0.242012	51	0.239358	0.263445
51	0.266423	0.290833	52	0.287634	0.311824
52	0.315360	0.339887	53	0.336135	0.360447
53	0.364550	0.389214	54	0.384902	0.409357
54	0.414037	0.438859	55	0.433976	0.458595
55	0.463863	0.488868	56	0.483400	0.508206
56	0.514077	0.539287	57	0.533222	0.558238
57	0.564727	0.590168	58	0.583489	0.608740
58	0.615865	0.641563	59	0.634253	0.659765
59	0.667546	0.693529	60	0.685567	0.711369
60	0.719828	0.746127	61	0.737491	0.763613
61	0.772775	0.799423	62	0.790087	0.816561
62	0.826455	0.853487	63	0.843422	0.870283
63	0.880941	0.908395	64	0.897570	0.924856
64	0.936313	0.964232	65	0.952610	0.980363
65	0.992660	1.021089	66	1.008629	1.036896
66	1.050079	1.079069	67	1.065725	1.094555
67	1.108676	1.138283	68	1.124004	1.153454
68	1.168572	1.198860	69	1.183586	1.213717
69	1.229899	1.260939	70	1.244603	1.275488
70	1.292810	1.324682	71	1.307206	1.338924
71	1.357477	1.390271	72	1.371567	1.404210
72	1.424095	1.457918	73	1.437882	1.471554
73	1.492891	1.527864	74	1.506377	1.541199
74	1.564130	1.600396	75	1.577315	1.613430
75	1.638122	1.675848	76	1.651006	1.688582
76	1.715235	1.754622	77	1.727818	1.767054
77	1.795912	1.837203	78	1.808193	1.849332
78	1.880694	1.924185	79	1.892670	1.936008
79	1.970248	2.016311	80	1.981916	2.027824
80	2.065418	2.114524	81	2.076772	2.125721
81	2.167286	2.220048	82	2.178322	2.230923
82	2.277286	2.334524	83	2.287995	2.345066
83	2.397369	2.460214	84	2.407738	2.470411
84	2.530298	2.600382	85	2.540313	2.610215
85	2.680189	2.759997	86	2.689829	2.769443
86	2.853606	2.947215	87	2.862841	2.956239
87	3.062085	3.176955	88	3.070871	3.185503
88	3.329321	3.481686	89	3.337583	3.489662
89	3.721044	3.960401	90	3.728626	3.967589

```
          ERROR   =  0.000336           ERROR   =  0.000329
          ENTROPY =  6.179978           ENTROPY =  6.195929
```

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N =	91		N =	92	
J	X	Y	J	X	Y
46	-0.023601	0.000000	47	0.000000	0.023345
47	0.023601	0.047202	48	0.046698	0.070052
48	0.070820	0.094439	49	0.093431	0.116810
49	0.118093	0.141746	50	0.140231	0.163653
50	0.165453	0.189160	51	0.187134	0.210616
51	0.212938	0.236715	52	0.234175	0.257734
52	0.260583	0.284450	53	0.281389	0.305044
53	0.308426	0.332402	54	0.328814	0.352583
54	0.356506	0.380610	55	0.376486	0.400389
55	0.404862	0.429115	56	0.424446	0.448502
56	0.453537	0.477958	57	0.472733	0.496964
57	0.502572	0.527185	58	0.521390	0.545817
58	0.552013	0.576841	59	0.570463	0.595109
59	0.601909	0.626976	60	0.619999	0.644888
60	0.652309	0.677642	61	0.670047	0.695205
61	0.703269	0.728895	62	0.720661	0.746116
62	0.754845	0.780794	63	0.771898	0.797680
63	0.807099	0.833404	64	0.823821	0.849961
64	0.860099	0.886794	65	0.876495	0.903028
65	0.913917	0.941041	66	0.929993	0.956957
66	0.968634	0.996226	67	0.984393	1.011830
67	1.024334	1.052442	68	1.039784	1.067737
68	1.081116	1.109790	69	1.096259	1.124780
69	1.139085	1.168380	70	1.153925	1.183070
70	1.198360	1.228339	71	1.212901	1.242732
71	1.259073	1.289808	72	1.273319	1.303906
72	1.321376	1.352945	73	1.335328	1.366751
73	1.385439	1.417934	74	1.399100	1.431449
74	1.451458	1.484982	75	1.464829	1.498209
75	1.519658	1.554333	76	1.532740	1.567272
76	1.590302	1.626270	77	1.603096	1.638921
77	1.663699	1.701127	78	1.676206	1.713490
78	1.740216	1.779305	79	1.752434	1.791378
79	1.820295	1.861285	80	1.832223	1.873068
80	1.904473	1.947662	81	1.916109	1.959151
81	1.993418	2.039174	82	2.004758	2.050365
82	2.087968	2.136762	83	2.099007	2.147649
83	2.189204	2.241647	84	2.199937	2.252224
84	2.298555	2.355464	85	2.308973	2.365721
85	2.417967	2.480469	86	2.428057	2.490394
86	2.550194	2.619918	87	2.559943	2.629492
87	2.699341	2.778765	88	2.708729	2.787965
88	2.871955	2.965146	89	2.880952	2.973938
89	3.079543	3.193941	90	3.088105	3.202272
90	3.345739	3.497537	91	3.353794	3.505315
91	3.736113	3.974689	92	3.743508	3.981702

	ERROR =	0.000321		ERROR =	0.000315
	ENTROPY =	6.211706		ENTROPY =	6.227312

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N =		93	N =		94
J	X	Y	J	X	Y
47	-0.023099	0.000000	48	0.000000	0.022853
48	0.023098	0.046197	49	0.045714	0.068576
49	0.069312	0.092427	50	0.091461	0.114346
50	0.115575	0.138723	51	0.137271	0.160196
51	0.161920	0.185118	52	0.183177	0.206159
52	0.208382	0.231646	53	0.229213	0.252267
53	0.254995	0.278343	54	0.275411	0.298555
54	0.301792	0.325242	55	0.321806	0.345057
55	0.348812	0.372381	56	0.368433	0.391810
56	0.396090	0.419798	57	0.415329	0.438849
57	0.443665	0.467531	58	0.462532	0.486215
58	0.491577	0.515622	59	0.510080	0.533946
59	0.539868	0.564114	60	0.558017	0.582087
60	0.588584	0.613053	61	0.606385	0.630682
61	0.637769	0.662486	62	0.655231	0.679779
62	0.687475	0.712464	63	0.704603	0.729428
63	0.737753	0.763043	64	0.754556	0.779684
64	0.788662	0.814281	65	0.805144	0.830605
65	0.840261	0.866242	66	0.856429	0.882254
66	0.892618	0.918994	67	0.908477	0.934700
67	0.945804	0.972613	68	0.961358	0.988017
68	0.999897	1.027181	69	1.015152	1.042287
69	1.054984	1.082788	70	1.069944	1.097601
70	1.111161	1.139534	71	1.125829	1.154057
71	1.168532	1.197530	72	1.182912	1.211767
72	1.227216	1.256902	73	1.241311	1.270855
73	1.287345	1.317788	74	1.301157	1.331460
74	1.349067	1.380347	75	1.362600	1.393740
75	1.412554	1.444762	76	1.425809	1.457877
76	1.478000	1.511239	77	1.490978	1.524078
77	1.545630	1.580020	78	1.558331	1.592584
78	1.615704	1.651388	79	1.628130	1.663676
79	1.688532	1.725675	80	1.700681	1.737687
80	1.764478	1.803280	81	1.776351	1.815015
81	1.843983	1.884685	82	1.855577	1.896140
82	1.927582	1.970480	83	1.938896	1.981652
83	2.015941	2.061402	84	2.026970	2.072288
84	2.109895	2.158389	85	2.120635	2.168983
85	2.210524	2.262659	86	2.220968	2.272954
86	2.319250	2.375841	87	2.329391	2.385827
87	2.438014	2.500187	88	2.447840	2.509852
88	2.569564	2.638941	89	2.579060	2.648268
89	2.717994	2.797047	90	2.727140	2.806013
90	2.889833	2.982618	91	2.898601	2.991189
91	3.096559	3.210499	92	3.104907	3.218624
92	3.361748	3.512997	93	3.369604	3.520585
93	3.750814	3.988631	94	3.758031	3.995478
	ERROR =	0.000308		ERROR =	0.000301
	ENTROPY =	6.242751		ENTROPY =	6.258027

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 95		
J	X	Y
48	-0.022617	0.000000
49	0.022617	0.045234
50	0.067866	0.090499
51	0.113162	0.135826
52	0.158536	0.181246
53	0.204018	0.226791
54	0.249642	0.272493
55	0.295439	0.318386
56	0.341445	0.364503
57	0.387692	0.410881
58	0.434218	0.457555
59	0.481059	0.504563
60	0.528255	0.551947
61	0.575847	0.599747
62	0.623877	0.648008
63	0.672393	0.696778
64	0.721442	0.746106
65	0.771077	0.796048
66	0.821354	0.846660
67	0.872333	0.898005
68	0.924079	0.950153
69	0.976664	1.003176
70	1.030166	1.057156
71	1.084670	1.112184
72	1.140270	1.168357
73	1.197072	1.225787
74	1.255193	1.284598
75	1.314763	1.344928
76	1.375932	1.406936
77	1.438868	1.470801
78	1.503766	1.536732
79	1.570850	1.604967
80	1.640378	1.675790
81	1.712660	1.749530
82	1.788058	1.826586
83	1.867012	1.907437
84	1.950055	1.992673
85	2.037850	2.083027
86	2.131232	2.179436
87	2.231274	2.283113
88	2.339398	2.395683
89	2.457538	2.519392
90	2.588434	2.657476
91	2.736171	2.814865
92	2.907260	2.999654
93	3.113152	3.226649
94	3.377365	3.528081
95	3.765163	4.002244

ERROR   = 0.000295
ENTROPY = 6.273142

N = 96		
J	X	Y
49	0.000000	0.022382
50	0.044771	0.067160
51	0.089572	0.111984
52	0.134433	0.156883
53	0.179385	0.201887
54	0.224457	0.247028
55	0.269683	0.292338
56	0.315093	0.337848
57	0.360721	0.383593
58	0.406600	0.429607
59	0.452767	0.475927
60	0.499258	0.522589
61	0.546111	0.569634
62	0.593368	0.617102
63	0.641071	0.665039
64	0.689265	0.713491
65	0.738000	0.762508
66	0.787326	0.812143
67	0.837299	0.862455
68	0.887980	0.913505
69	0.939433	0.965361
70	0.991729	1.018097
71	1.044946	1.071795
72	1.099169	1.126542
73	1.154491	1.182440
74	1.211018	1.239597
75	1.268867	1.298136
76	1.328167	1.358198
77	1.389068	1.419939
78	1.451739	1.483538
79	1.516371	1.549204
80	1.583190	1.617176
81	1.652455	1.687733
82	1.724471	1.761209
83	1.799604	1.837998
84	1.878290	1.918581
85	1.961063	2.003545
86	2.048584	2.093624
87	2.141687	2.189751
88	2.241445	2.293139
89	2.349276	2.405412
90	2.467111	2.528810
91	2.597689	2.666568
92	2.745088	2.823608
93	2.915811	3.008014
94	3.121296	3.234577
95	3.385033	3.535489
96	3.772210	4.008932

ERROR   = 0.000289
ENTROPY = 6.288101

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N =	97			N =	98	
J	X	Y		J	X	Y
49	-0.022155	0.000000		50	0.000000	0.021929
50	0.022155	0.044310		51	0.043866	0.065802
51	0.066480	0.088650		52	0.087760	0.109718
52	0.110848	0.133047		53	0.131711	0.153704
53	0.155290	0.177532		54	0.175746	0.197789
54	0.199833	0.222135		55	0.219896	0.242003
55	0.244510	0.266885		56	0.264189	0.286375
56	0.289350	0.311814		57	0.308655	0.330936
57	0.334384	0.356954		58	0.353326	0.375717
58	0.379646	0.402338		59	0.398234	0.420750
59	0.425169	0.448000		60	0.443410	0.466070
60	0.470988	0.493975		61	0.488891	0.511711
61	0.517138	0.540301		62	0.534711	0.557711
62	0.563659	0.587017		63	0.580909	0.604107
63	0.610591	0.634164		64	0.627524	0.650941
64	0.657975	0.681786		65	0.674598	0.698256
65	0.705857	0.729928		66	0.722176	0.746097
66	0.754285	0.778642		67	0.770306	0.794515
67	0.803310	0.827979		68	0.819038	0.843562
68	0.852988	0.877997		69	0.868428	0.893294
69	0.903378	0.928759		70	0.918535	0.943775
70	0.954545	0.980331		71	0.969422	0.995070
71	1.006559	1.032787		72	1.021162	1.047253
72	1.059498	1.086209		73	1.073829	1.100405
73	1.113446	1.140684		74	1.127509	1.154613
74	1.168497	1.196311		75	1.182295	1.209977
75	1.224756	1.253201		76	1.238291	1.266606
76	1.282338	1.311476		77	1.295614	1.324622
77	1.341375	1.371275		78	1.354393	1.384163
78	1.402014	1.432754		79	1.414775	1.445387
79	1.464424	1.496094		80	1.476930	1.508473
80	1.528797	1.561501		81	1.541049	1.573625
81	1.595357	1.629213		82	1.607355	1.641084
82	1.664363	1.699512		83	1.676107	1.711129
83	1.736120	1.772727		84	1.747610	1.784090
84	1.810992	1.849256		85	1.822226	1.860362
85	1.889415	1.929575		86	1.900392	1.940422
86	1.971923	2.014272		87	1.982640	2.024858
87	2.059176	2.104080		88	2.069629	2.114400
88	2.152006	2.199931		89	2.162190	2.209980
89	2.251484	2.303036		90	2.261393	2.312807
90	2.359026	2.415016		91	2.368653	2.424499
91	2.476563	2.538110		92	2.485896	2.547293
92	2.606828	2.675546		93	2.615853	2.684413
93	2.753894	2.832242		94	2.762592	2.840772
94	2.924258	3.016273		95	2.932602	3.024432
95	3.129341	3.242410		96	3.137291	3.250150
96	3.392610	3.542809		97	3.400097	3.550044
97	3.779176	4.015542		98	3.786061	4.022078
	ERROR =	0.000283			ERROR =	0.000278
	ENTROPY =	6.302906			ENTROPY =	6.317560

36

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N =	99		N =	100	
J	X	Y	J	X	Y
50	-0.021712	0.000000	51	0.000000	0.021495
51	0.021712	0.043423	52	0.042997	0.064498
52	0.065149	0.086874	53	0.086020	0.107541
53	0.108627	0.130380	54	0.129096	0.150651
54	0.152174	0.173968	55	0.172253	0.193854
55	0.195817	0.217667	56	0.215516	0.237179
56	0.239585	0.261504	57	0.258915	0.280652
57	0.283507	0.305510	58	0.302477	0.324302
58	0.327612	0.349714	59	0.346231	0.368160
59	0.371930	0.394147	60	0.390207	0.412255
60	0.416493	0.438840	61	0.434437	0.456619
61	0.461334	0.483828	62	0.478951	0.501284
62	0.506487	0.529145	63	0.523785	0.546285
63	0.551986	0.574827	64	0.568972	0.591659
64	0.597870	0.620912	65	0.614550	0.637442
65	0.644177	0.667441	66	0.660558	0.683674
66	0.690949	0.714457	67	0.707037	0.730399
67	0.738232	0.762006	68	0.754031	0.777662
68	0.786071	0.810136	69	0.801587	0.825511
69	0.834517	0.858899	70	0.849755	0.873999
70	0.883626	0.908354	71	0.898590	0.923181
71	0.933457	0.958560	72	0.948150	0.973120
72	0.984072	1.009584	73	0.998500	1.023880
73	1.035543	1.061501	74	1.049708	1.075536
74	1.087945	1.114389	75	1.101852	1.128167
75	1.141363	1.168337	76	1.155014	1.181860
76	1.195890	1.223443	77	1.209287	1.236715
77	1.251630	1.279816	78	1.264776	1.292838
78	1.308698	1.337579	79	1.321595	1.350353
79	1.367224	1.396869	80	1.379875	1.409397
80	1.427356	1.457843	81	1.439761	1.470125
81	1.489261	1.520679	82	1.501421	1.532717
82	1.553131	1.585583	83	1.565047	1.597378
83	1.619188	1.652793	84	1.630861	1.664344
84	1.687691	1.722589	85	1.699120	1.733896
85	1.758945	1.795300	86	1.770129	1.806362
86	1.833310	1.871321	87	1.844249	1.882136
87	1.911224	1.951128	88	1.921915	1.961694
88	1.993217	2.035306	89	2.003657	2.045620
89	2.079947	2.124588	90	2.090133	2.134645
90	2.172244	2.219901	91	2.182171	2.229697
91	2.271178	2.322454	92	2.280839	2.331981
92	2.378159	2.433864	93	2.387547	2.443113
93	2.495113	2.556363	94	2.504217	2.565322
94	2.624768	2.693172	95	2.633574	2.701825
95	2.771185	2.849198	96	2.779674	2.857523
96	2.940846	3.032494	97	2.948992	3.040461
97	3.145146	3.257799	98	3.152910	3.265359
98	3.407497	3.557195	99	3.414812	3.564265
99	3.792867	4.028540	100	3.799597	4.034929

	ERROR =	0.000272		ERROR =	0.000267
	ENTROPY =	6.332067		ENTROPY =	6.346430

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 101			N = 102		
J	X	Y	J	X	Y
51	-0.021286	0.000000	52	0.000000	0.021077
52	0.021286	0.042572	53	0.042161	0.063245
53	0.063870	0.085169	54	0.084347	0.105450
54	0.106494	0.127818	55	0.126584	0.147718
55	0.149181	0.170545	56	0.168896	0.190074
56	0.191960	0.213375	57	0.211309	0.232544
57	0.234856	0.256337	58	0.253849	0.275154
58	0.277897	0.299457	59	0.296542	0.317931
59	0.321110	0.342763	60	0.339417	0.360903
60	0.364524	0.386285	61	0.382501	0.404099
61	0.408168	0.430052	62	0.425823	0.447547
62	0.452073	0.474095	63	0.469413	0.491279
63	0.496271	0.518447	64	0.513303	0.535326
64	0.540794	0.563142	65	0.557524	0.579723
65	0.585678	0.608215	66	0.602113	0.624503
66	0.630959	0.653703	67	0.647104	0.669705
67	0.676675	0.699647	68	0.692536	0.715368
68	0.722868	0.746089	69	0.738451	0.761533
69	0.769581	0.793073	70	0.784890	0.808246
70	0.816861	0.840649	71	0.831900	0.855555
71	0.864758	0.888867	72	0.879532	0.903510
72	0.913326	0.937784	73	0.927839	0.952169
73	0.962623	0.987461	74	0.976879	1.001590
74	1.012713	1.037964	75	1.026716	1.051841
75	1.063665	1.089365	76	1.077418	1.102994
76	1.115555	1.141744	77	1.129060	1.155127
77	1.168467	1.195189	78	1.181727	1.208328
78	1.222493	1.249797	79	1.235511	1.262694
79	1.277736	1.305676	80	1.290514	1.318334
80	1.334312	1.362948	81	1.346851	1.375369
81	1.392349	1.421750	82	1.404652	1.433935
82	1.451995	1.482239	83	1.464062	1.494189
83	1.513416	1.544592	84	1.525248	1.556307
84	1.576803	1.609013	85	1.588400	1.620494
85	1.642377	1.675741	86	1.653741	1.686988
86	1.710397	1.745053	87	1.721526	1.756065
87	1.781166	1.817279	88	1.792060	1.828054
88	1.855045	1.892810	89	1.865701	1.903348
89	1.932467	1.972124	90	1.942885	1.982422
90	2.013963	2.055803	91	2.024139	2.065857
91	2.100189	2.144576	92	2.110120	2.154383
92	2.191973	2.239370	93	2.201653	2.248924
93	2.290380	2.341390	94	2.299804	2.350684
94	2.396819	2.452248	95	2.405979	2.461273
95	2.513210	2.574172	96	2.522095	2.582917
96	2.642274	2.710375	97	2.650870	2.718823
97	2.788063	2.865750	98	2.796352	2.873881
98	2.957042	3.048334	99	2.964999	3.056117
99	3.160583	3.272832	100	3.168169	3.280220
100	3.422043	3.571254	101	3.429193	3.578166
101	3.806251	4.041248	102	3.812832	4.047498

	N = 101		N = 102
ERROR =	0.000262	ERROR =	0.000256
ENTROPY =	6.360651	ENTROPY =	6.374733

N =	103		N =	104	
J	X	Y	J	X	Y
52	-0.020876	0.000000	53	0.000000	0.020676
53	0.020876	0.041752	54	0.041358	0.062039
54	0.062641	0.083529	55	0.082739	0.103438
55	0.104442	0.125355	56	0.124167	0.144896
56	0.146304	0.167254	57	0.165667	0.186438
57	0.188252	0.209250	58	0.207262	0.228087
58	0.230310	0.251371	59	0.248977	0.269868
59	0.272505	0.293640	60	0.290837	0.311807
60	0.314863	0.336085	61	0.332868	0.353929
61	0.357409	0.378733	62	0.375096	0.396262
62	0.400172	0.421612	63	0.417547	0.438833
63	0.443181	0.464750	64	0.460252	0.481671
64	0.486465	0.508179	65	0.503238	0.524805
65	0.530055	0.551930	66	0.546536	0.568267
66	0.573983	0.596036	67	0.590179	0.612091
67	0.618284	0.640532	68	0.634200	0.656309
68	0.662993	0.685455	69	0.678635	0.700960
69	0.708149	0.730843	70	0.723521	0.746081
70	0.753792	0.776740	71	0.768898	0.791715
71	0.799964	0.823188	72	0.814810	0.837905
72	0.846712	0.870236	73	0.861301	0.884698
73	0.894085	0.917935	74	0.908422	0.932147
74	0.942138	0.966340	75	0.956226	0.980305
75	0.990926	1.015513	76	1.004770	1.029234
76	1.040515	1.065517	77	1.054116	1.078998
77	1.090972	1.116427	78	1.104334	1.129669
78	1.142373	1.168319	79	1.155498	1.181326
79	1.194800	1.221282	80	1.207691	1.234056
80	1.248347	1.275412	81	1.261005	1.287955
81	1.303115	1.330818	82	1.315543	1.343131
82	1.359219	1.387620	83	1.371418	1.399705
83	1.416787	1.445955	84	1.428759	1.457813
84	1.475966	1.505978	85	1.487712	1.517610
85	1.536922	1.567866	86	1.548442	1.579273
86	1.599845	1.631824	87	1.611139	1.643006
87	1.664955	1.698087	88	1.676025	1.709044
88	1.732511	1.766934	89	1.743354	1.777664
89	1.802813	1.838692	90	1.813429	1.849195
90	1.876222	1.913752	91	1.886610	1.924026
91	1.953171	1.992590	92	1.963329	2.002632
92	2.034188	2.075787	93	2.044113	2.085593
93	2.119928	2.164069	94	2.129615	2.173637
94	2.211215	2.258361	95	2.220661	2.267684
95	2.309114	2.359866	96	2.318311	2.368938
			97	2.423970	2.479002
96	2.415028	2.470191	98	2.539550	2.600098
97	2.530874	2.591558	99	2.667761	2.735425
98	2.659365	2.727173	100	2.812644	2.889863
99	2.804545	2.881918	101	2.980640	3.071418
100	2.972865	3.063811	102	3.183083	3.294748
101	3.175668	3.287525	103	3.443254	3.591760
102	3.436263	3.585001	104	3.825779	4.059797
103	3.819341	4.053681			

ERROR = 0.000252	ERROR = 0.000247
ENTROPY = 6.388678	ENTROPY = 6.402491

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 105			N = 106		
J	X	Y	J	X	Y
53	-0.020482	0.000000	54	0.000000	0.020289
54	0.020482	0.040964	55	0.040584	0.060879
55	0.061458	0.081952	56	0.081190	0.101502
56	0.102468	0.122985	57	0.121842	0.142181
57	0.143536	0.164087	58	0.162560	0.182939
58	0.184685	0.205282	59	0.203368	0.223798
59	0.225938	0.246594	60	0.244290	0.264782
60	0.267320	0.288046	61	0.285349	0.305915
61	0.308855	0.329664	62	0.326568	0.347221
62	0.350568	0.371473	63	0.367974	0.388726
63	0.392486	0.413500	64	0.409591	0.430455
64	0.434636	0.455771	65	0.451445	0.472436
65	0.477044	0.498316	66	0.493566	0.514696
66	0.519740	0.541164	67	0.535980	0.557264
67	0.562755	0.584345	68	0.578718	0.600172
68	0.606119	0.627893	69	0.621812	0.643451
69	0.649867	0.671842	70	0.665294	0.687136
70	0.694034	0.716227	71	0.709200	0.731263
71	0.738657	0.761088	72	0.753566	0.775869
72	0.783776	0.806465	73	0.798433	0.820996
73	0.829434	0.852403	74	0.843842	0.866688
74	0.875675	0.898948	75	0.889839	0.912991
75	0.922550	0.946152	76	0.936473	0.959955
76	0.970110	0.994069	77	0.983796	1.007636
77	1.018414	1.042759	78	1.031865	1.056094
78	1.067523	1.092288	79	1.080743	1.105392
79	1.117507	1.142726	80	1.130497	1.155603
80	1.168440	1.194153	81	1.181203	1.206804
81	1.220404	1.246654	82	1.232943	1.259082
82	1.273491	1.300327	83	1.285807	1.312533
83	1.327803	1.355279	84	1.339899	1.367264
84	1.383454	1.411629	85	1.395330	1.423396
85	1.440572	1.469515	86	1.452230	1.481064
86	1.499303	1.529091	87	1.510743	1.540422
87	1.559811	1.590532	88	1.571034	1.601647
88	1.622288	1.654044	89	1.633294	1.664941
89	1.686952	1.719860	90	1.697741	1.730540
90	1.754059	1.788259	91	1.764630	1.798721
91	1.823912	1.859566	92	1.834264	1.869808
92	1.896869	1.934172	93	1.907001	1.944193
93	1.973361	2.012550	94	1.983270	2.022347
94	2.053915	2.095281	95	2.063599	2.104851
95	2.139185	2.183089	96	2.148640	2.192428
96	2.229993	2.276896	97	2.239213	2.285999
97	2.327399	2.377902	98	2.336380	2.386761
98	2.432806	2.487710	99	2.441539	2.496317
99	2.548124	2.608538	100	2.556600	2.616882
100	2.676061	2.743583	101	2.684265	2.751648
101	2.820650	2.897717	102	2.828566	2.905483
102	2.988328	3.078940	103	2.995931	3.086378
103	3.190416	3.301891	104	3.197667	3.308957
104	3.450169	3.598447	105	3.457009	3.605061
105	3.832147	4.065848	106	3.838448	4.071836

ERROR = 0.000242	ERROR = 0.000238
ENTROPY = 6.416172	ENTROPY = 6.429724

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 107

J	X	Y
54	-0.020103	0.000000
55	0.020103	0.040205
56	0.060319	0.080432
57	0.100568	0.120703
58	0.140871	0.161039
59	0.181251	0.201462
60	0.221729	0.241996
61	0.262329	0.282662
62	0.303074	0.323485
63	0.343987	0.364488
64	0.385093	0.405697
65	0.426417	0.447137
66	0.467985	0.488834
67	0.509825	0.530816
68	0.551965	0.573113
69	0.594434	0.615754
70	0.637263	0.658772
71	0.680486	0.702200
72	0.724137	0.746074
73	0.768253	0.790432
74	0.812874	0.835315
75	0.858041	0.880766
76	0.903799	0.926832
77	0.950197	0.973562
78	0.997288	1.021013
79	1.045128	1.069242
80	1.093779	1.118315
81	1.143309	1.168303
82	1.193793	1.219283
83	1.245313	1.271343
84	1.297959	1.324576
85	1.351834	1.379092
86	1.407050	1.435009
87	1.463736	1.492463
88	1.522035	1.551608
89	1.582114	1.612620
90	1.644160	1.675701
91	1.708394	1.741087
92	1.775070	1.809053
93	1.844489	1.879925
94	1.917009	1.954092
95	1.993060	2.032027
96	2.073167	2.114307
97	2.157982	2.201657
98	2.248326	2.294995
99	2.345256	2.395518
100	2.450172	2.504826
101	2.564978	2.625131
102	2.692377	2.759623
103	2.836393	2.913163
104	3.003449	3.093734
105	3.204840	3.315946
106	3.463775	3.611605
107	3.844683	4.077761

ERROR = 0.000233
ENTROPY = 6.443151

N = 108

J	X	Y
55	0.000000	0.019917
56	0.039839	0.059761
57	0.079699	0.099637
58	0.119601	0.139566
59	0.159567	0.179569
60	0.199619	0.219668
61	0.239777	0.259885
62	0.280064	0.300243
63	0.320504	0.340765
64	0.361119	0.381474
65	0.401934	0.422394
66	0.442973	0.463552
67	0.484263	0.504974
68	0.525830	0.546686
69	0.567702	0.588718
70	0.609908	0.631099
71	0.652480	0.673862
72	0.695451	0.717039
73	0.738853	0.760667
74	0.782725	0.804783
75	0.827105	0.849427
76	0.872035	0.894643
77	0.917560	0.940477
78	0.963728	0.986979
79	1.010591	1.034204
80	1.058207	1.082210
81	1.106636	1.131063
82	1.155947	1.180832
83	1.206214	1.231596
84	1.257518	1.283440
85	1.309951	1.336461
86	1.363613	1.390765
87	1.418618	1.446471
88	1.475094	1.503716
89	1.533184	1.562652
90	1.593053	1.623455
91	1.654891	1.686327
92	1.718915	1.751503
93	1.785381	1.819259
94	1.854589	1.889919
95	1.926896	1.963873
96	2.002732	2.041591
97	2.082621	2.123652
98	2.167215	2.210778
99	2.257332	2.303886
100	2.354030	2.404174
101	2.458705	2.513237
102	2.573262	2.633286
103	2.700397	2.767508
104	2.844133	2.920759
105	3.010885	3.101011
106	3.211935	3.322859
107	3.470470	3.618080
108	3.850853	4.083625

ERROR = 0.000229
ENTROPY = 6.456453

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 109			N = 110		
J	X	Y	J	X	Y
55	-0.019737	0.000000	56	0.000000	0.019558
56	0.019737	0.039474	57	0.039121	0.058684
57	0.059221	0.078969	58	0.078261	0.097839
58	0.098736	0.118504	59	0.117442	0.137045
59	0.138303	0.158102	60	0.156683	0.176321
60	0.177942	0.197782	61	0.196005	0.215688
61	0.217674	0.237566	62	0.235428	0.255167
62	0.257522	0.277477	63	0.274973	0.294779
63	0.297506	0.317535	64	0.314662	0.334545
64	0.337649	0.357763	65	0.354517	0.374489
65	0.377975	0.398186	66	0.394561	0.414633
66	0.418506	0.438827	67	0.434817	0.455001
67	0.459268	0.479710	68	0.475309	0.495618
68	0.500287	0.520863	69	0.516063	0.536509
69	0.541587	0.562312	70	0.557105	0.577701
70	0.583199	0.604085	71	0.598462	0.619222
71	0.625149	0.646213	72	0.640163	0.661103
72	0.667470	0.688727	73	0.682239	0.703374
73	0.710193	0.731660	74	0.724721	0.746068
74	0.753353	0.775047	75	0.767644	0.789220
75	0.796987	0.818926	76	0.811044	0.832868
76	0.841132	0.863337	77	0.854959	0.877051
77	0.885830	0.908323	78	0.899432	0.921812
78	0.931127	0.953930	79	0.944505	0.967198
79	0.977070	1.000209	80	0.990228	1.013258
80	1.023711	1.047213	81	1.036652	1.060046
81	1.071107	1.095001	82	1.083833	1.107620
82	1.119319	1.143638	83	1.131833	1.156045
83	1.168415	1.193193	84	1.180718	1.205391
84	1.218469	1.243745	85	1.230563	1.255736
85	1.269562	1.295380	86	1.281450	1.307164
86	1.321786	1.348192	87	1.333468	1.359771
87	1.375240	1.402288	88	1.386718	1.413664
88	1.430038	1.457788	89	1.441313	1.468961
89	1.486307	1.514826	90	1.497380	1.525798
90	1.544192	1.573557	91	1.555062	1.584327
91	1.603856	1.634155	92	1.614525	1.644723
92	1.665488	1.696822	93	1.675956	1.707188
93	1.729307	1.761792	94	1.739572	1.771957
94	1.795567	1.829341	95	1.805629	1.839302
95	1.864567	1.899793	96	1.874426	1.909549
96	1.936665	1.973537	97	1.946318	1.983086
97	2.012289	2.051042	98	2.021735	2.060383
98	2.091965	2.132887	99	2.101199	2.142015
99	2.176340	2.219793	100	2.185360	2.228704
100	2.266234	2.312676	101	2.275035	2.321366
101	2.362704	2.412731	102	2.371279	2.421192
102	2.467142	2.521554	103	2.475485	2.529778
103	2.581452	2.641351	104	2.589552	2.649327
104	2.708329	2.775307	105	2.716174	2.783020
105	2.851789	2.928271	106	2.859361	2.935702
106	3.018240	3.108209	107	3.025516	3.115330
107	3.218954	3.329700	108	3.225899	3.336468
108	3.477094	3.624488	109	3.483648	3.630829
109	3.856958	4.089429	110	3.863002	4.095175

	N = 109		N = 110
ERROR =	0.000225	ERROR =	0.000221
ENTROPY =	6.469634	ENTROPY =	6.482696

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 111			N = 112		
J	X	Y	J	X	Y
56	-0.019385	0.000000	57	0.000000	0.019211
57	0.019384	0.038769	58	0.038428	0.057644
58	0.058163	0.077557	59	0.076875	0.096105
59	0.096971	0.116384	60	0.115360	0.134614
60	0.135827	0.155270	61	0.153901	0.173189
61	0.174752	0.194234	62	0.192520	0.211850
62	0.213766	0.233297	63	0.231234	0.250618
63	0.252888	0.272479	64	0.270064	0.289511
64	0.292140	0.311801	65	0.309031	0.328550
65	0.331542	0.351284	66	0.348154	0.367758
66	0.371117	0.390950	67	0.387456	0.407154
67	0.410887	0.430823	68	0.426959	0.446763
68	0.450874	0.470925	69	0.466685	0.486606
69	0.491103	0.511282	70	0.506658	0.526709
70	0.531599	0.551917	71	0.546903	0.567096
71	0.572388	0.592859	72	0.587445	0.607794
72	0.613497	0.634135	73	0.628312	0.648830
73	0.654955	0.675775	74	0.669532	0.690234
74	0.696791	0.717808	75	0.711135	0.732036
75	0.739039	0.760269	76	0.753152	0.774269
76	0.781730	0.803192	77	0.795618	0.816967
77	0.824902	0.846613	78	0.838567	0.860167
78	0.868593	0.890574	79	0.882039	0.903910
79	0.912844	0.935115	80	0.926073	0.948237
80	0.957700	0.980284	81	0.970715	0.993193
81	1.003207	1.026130	82	1.016011	1.038829
82	1.049418	1.072706	83	1.062014	1.085198
83	1.096389	1.120071	84	1.108778	1.132358
84	1.144180	1.168289	85	1.156366	1.180373
85	1.192859	1.217430	86	1.204843	1.229313
86	1.242500	1.267571	87	1.254283	1.279254
87	1.293184	1.318797	88	1.304768	1.330282
88	1.345000	1.371203	89	1.356387	1.382492
89	1.398050	1.424897	90	1.409240	1.435989
90	1.452446	1.479995	91	1.463441	1.490892
91	1.508314	1.536633	92	1.519114	1.547336
92	1.565799	1.594964	93	1.576404	1.605472
93	1.625064	1.655163	94	1.635474	1.665476
94	1.686296	1.717430	95	1.696513	1.727549
95	1.749715	1.781999	96	1.759736	1.791923
96	1.815572	1.849145	97	1.825398	1.858872
97	1.884168	1.919191	98	1.893796	1.928720
98	1.955858	1.992525	99	1.965287	2.001854
99	2.031070	2.069615	100	2.040298	2.078742
100	2.110327	2.151039	101	2.119351	2.159960
101	2.194277	2.237514	102	2.203093	2.246226
102	2.283736	2.329957	103	2.292339	2.338453
103	2.379758	2.429559	104	2.388143	2.437833
104	2.483735	2.537911	105	2.491894	2.545955
105	2.597563	2.657216	106	2.605487	2.665019
106	2.723933	2.790650	107	2.731609	2.798198
107	2.866852	2.943054	108	2.874263	2.950328
108	3.032715	3.122376	109	3.039838	3.129348
109	3.232771	3.343166	110	3.239571	3.349794
110	3.490135	3.637104	111	3.496555	3.643316
111	3.868983	4.100862	112	3.874905	4.106494

```
              ERROR   = 0.000217                      ERROR   = 0.000213
              ENTROPY = 6.495640                      ENTROPY = 6.508469
```

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 113				N = 114		
J	X	Y		J	X	Y
57	-0.019044	0.000000		58	-0.000001	0.018876
58	0.019044	0.038088		59	0.037758	0.056640
59	0.057142	0.076195		60	0.075535	0.094430
60	0.095267	0.114339		61	0.113348	0.132266
61	0.133438	0.152538		62	0.151216	0.170165
62	0.171675	0.190812		63	0.189155	0.208146
63	0.209995	0.229179		64	0.227186	0.246227
64	0.248419	0.267659		65	0.265327	0.284427
65	0.286965	0.306271		66	0.303597	0.322766
66	0.325654	0.345036		67	0.342015	0.361264
67	0.364506	0.383975		68	0.380603	0.399942
68	0.403542	0.423109		69	0.419381	0.438820
69	0.442784	0.462460		70	0.458370	0.477920
70	0.482256	0.502051		71	0.497593	0.517265
71	0.521979	0.541907		72	0.537072	0.556879
72	0.561979	0.582051		73	0.576833	0.596787
73	0.602281	0.622511		74	0.616900	0.637014
74	0.642912	0.663313		75	0.657301	0.677587
75	0.683899	0.704486		76	0.698062	0.718536
76	0.725274	0.746062		77	0.739214	0.759891
77	0.767067	0.788072		78	0.780787	0.801683
78	0.809311	0.830551		79	0.822815	0.843947
79	0.852043	0.873535		80	0.865334	0.886720
80	0.895300	0.917065		81	0.908381	0.930041
81	0.939123	0.961181		82	0.951996	0.973952
82	0.983556	1.005930		83	0.996224	1.018497
83	1.028645	1.051361		84	1.041112	1.063727
84	1.074444	1.097527		85	1.086710	1.109694
85	1.121006	1.144486		86	1.133075	1.156456
86	1.168394	1.192302		87	1.180267	1.204077
87	1.216673	1.241044		88	1.228351	1.252626
88	1.265917	1.290789		89	1.277402	1.302179
89	1.316206	1.341623		90	1.327501	1.352822
90	1.367631	1.393640		91	1.378736	1.404649
91	1.420292	1.446944		92	1.431207	1.457765
92	1.474300	1.501656		93	1.485027	1.512288
93	1.529782	1.557908		94	1.540321	1.568353
94	1.586881	1.615854		95	1.597232	1.626111
95	1.645761	1.675667		96	1.655924	1.685736
96	1.706608	1.737548		97	1.716583	1.747429
97	1.769639	1.801730		98	1.779426	1.811422
98	1.835108	1.868486		99	1.844706	1.877989
99	1.903313	1.938140		100	1.912720	1.947451
100	1.974608	2.011077		101	1.983822	2.020194
101	2.049421	2.087766		102	2.058440	2.096687
102	2.128273	2.168781		103	2.137095	2.177502
103	2.211810	2.254840		104	2.220430	2.263358
104	2.300847	2.346855		105	2.309261	2.355165
105	2.396436	2.446016		106	2.404638	2.454111
106	2.499964	2.553912		107	2.507946	2.561782
107	2.613325	2.672738		108	2.621079	2.680375
108	2.739202	2.805666		109	2.746715	2.813055
109	2.881596	2.957525		110	2.888851	2.964647
110	3.046887	3.136248		111	3.053862	3.143076
111	3.246301	3.356355		112	3.252962	3.362848
112	3.502910	3.649466		113	3.509201	3.655553
113	3.880768	4.112069		114	3.886572	4.117590

ERROR =	0.000209		ERROR =	0.000206
ENTROPY =	6.521185		ENTROPY =	6.533790

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

	N = 115	
J	X	Y
58	-0.018716	0.000000
59	0.018716	0.037431
60	0.056156	0.074880
61	0.093622	0.112364
62	0.131132	0.149901
63	0.168704	0.187508
64	0.206356	0.225204
65	0.244105	0.263007
66	0.281971	0.300935
67	0.319972	0.339008
68	0.358127	0.377246
69	0.396458	0.415669
70	0.434983	0.454297
71	0.473725	0.493153
72	0.512706	0.532258
73	0.551948	0.571637
74	0.591475	0.611313
75	0.631313	0.651313
76	0.671488	0.691663
77	0.712028	0.732393
78	0.752962	0.773531
79	0.794321	0.815110
80	0.836137	0.857165
81	0.878448	0.899731
82	0.921289	0.942847
83	0.964702	0.986556
84	1.008729	1.030902
85	1.053419	1.075935
86	1.098821	1.121707
87	1.144992	1.168276
88	1.191991	1.215706
89	1.239885	1.264065
90	1.288747	1.313430
91	1.338658	1.363886
92	1.389706	1.415526
93	1.441991	1.468457
94	1.495626	1.522795
95	1.550735	1.578675
96	1.607462	1.636249
97	1.665970	1.695690
98	1.726444	1.757198
99	1.789101	1.821005
100	1.854195	1.887385
101	1.922021	1.956658
102	1.992934	2.029211
103	2.067361	2.105510
104	2.145820	2.186130
105	2.228957	2.271784
106	2.317585	2.363386
107	2.412753	2.462119
108	2.515845	2.569571
109	2.628752	2.687933
110	2.754150	2.820368
111	2.896032	2.971697
112	3.060767	3.149836
113	3.259557	3.369278
114	3.515430	3.661582
115	3.892320	4.123059

ERROR = 0.000202
ENTROPY = 6.546286

	N = 116	
J	X	Y
59	0.000000	0.018555
60	0.037113	0.055672
61	0.074244	0.092816
62	0.111409	0.130002
63	0.148625	0.167248
64	0.185910	0.204571
65	0.223281	0.241990
66	0.260756	0.279522
67	0.298354	0.317186
68	0.336093	0.355001
69	0.373993	0.392985
70	0.412072	0.431159
71	0.450352	0.469544
72	0.488853	0.508162
73	0.527597	0.547033
74	0.566607	0.586182
75	0.605907	0.625632
76	0.645521	0.665410
77	0.685476	0.705542
78	0.725799	0.746057
79	0.766520	0.786983
80	0.807669	0.828355
81	0.849279	0.870204
82	0.891385	0.912567
83	0.934025	0.955484
84	0.977239	0.998995
85	1.021071	1.043146
86	1.065566	1.087986
87	1.110776	1.133567
88	1.156757	1.179947
89	1.203568	1.227188
90	1.251275	1.275361
91	1.299951	1.324541
92	1.349677	1.374813
93	1.400542	1.426271
94	1.452645	1.479019
95	1.506098	1.533176
96	1.561026	1.588875
97	1.617572	1.646268
98	1.675897	1.705527
99	1.736190	1.766853
100	1.798665	1.830478
101	1.863576	1.896673
102	1.931217	1.965761
103	2.001944	2.038127
104	2.076181	2.114236
105	2.154449	2.194662
106	2.237390	2.280119
107	2.325818	2.371518
108	2.420780	2.470042
109	2.523659	2.577276
110	2.636344	2.695411
111	2.761508	2.827605
112	2.903139	2.978674
113	3.067601	3.156527
114	3.266085	3.375643
115	3.521597	3.667551
116	3.898013	4.128474

ERROR = 0.000199
ENTROPY = 6.558674

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 117				N = 118		
J	X	Y		J	X	Y
59	-0.018398	0.000000		60	0.000000	0.018243
60	0.018398	0.036797		61	0.036489	0.054736
61	0.055203	0.073610		62	0.072995	0.091254
62	0.092033	0.110457		63	0.109533	0.127812
63	0.128905	0.147353		64	0.146120	0.164428
64	0.165835	0.184317		65	0.182772	0.201117
65	0.202841	0.221365		66	0.219506	0.237896
66	0.239939	0.258514		67	0.256340	0.274783
67	0.277149	0.295783		68	0.293289	0.311796
68	0.314486	0.333189		69	0.330373	0.348951
69	0.351970	0.370751		70	0.367609	0.386267
70	0.389620	0.408489		71	0.405015	0.423764
71	0.427455	0.446421		72	0.442612	0.461460
72	0.465495	0.484569		73	0.480418	0.499376
73	0.503761	0.522953		74	0.518454	0.537533
74	0.542274	0.561596		75	0.556743	0.575953
75	0.581058	0.600520		76	0.595305	0.614658
76	0.620135	0.639750		77	0.634165	0.653672
77	0.659531	0.679311		78	0.673347	0.693021
78	0.699271	0.719230		79	0.712877	0.732732
79	0.739382	0.759534		80	0.752781	0.772831
80	0.779894	0.800254		81	0.793089	0.813348
81	0.820838	0.841422		82	0.833832	0.854316
82	0.862246	0.883070		83	0.875042	0.895767
83	0.904152	0.925235		84	0.916753	0.937738
84	0.946595	0.967956		85	0.959003	0.980267
85	0.989615	1.011274		86	1.001831	1.023395
86	1.033254	1.055233		87	1.045282	1.067168
87	1.077559	1.099884		88	1.089400	1.111633
88	1.122581	1.145277		89	1.134237	1.156842
89	1.168374	1.191472		90	1.179848	1.202854
90	1.215000	1.238529		91	1.226293	1.249731
91	1.262524	1.286519		92	1.273637	1.297542
92	1.311019	1.335518		93	1.321952	1.346363
93	1.360564	1.385609		94	1.371320	1.396277
94	1.411249	1.436888		95	1.421828	1.447379
95	1.463172	1.489457		96	1.473575	1.499772
96	1.516446	1.543436		97	1.526674	1.553575
97	1.571196	1.598956		98	1.581248	1.608921
98	1.627564	1.656171		99	1.637441	1.665960
99	1.685711	1.715252		100	1.695413	1.724866
100	1.745825	1.776399		101	1.755351	1.785837
101	1.808121	1.839844		102	1.817471	1.849105
102	1.872851	1.905858		103	1.882023	1.914941
103	1.940311	1.974763		104	1.949304	1.983667
104	2.010854	2.046944		105	2.019666	2.055666
105	2.084905	2.122866		106	2.093535	2.131403
106	2.162984	2.203102		107	2.171427	2.211451
107	2.245733	2.288364		108	2.253986	2.296522
108	2.333964	2.379563		109	2.342023	2.387524
109	2.428723	2.477882		110	2.436582	2.485639
110	2.531392	2.584902		111	2.539044	2.592448
111	2.643857	2.702811		112	2.651292	2.710136
112	2.768789	2.834767		113	2.775997	2.841858
113	2.910174	2.985580		114	2.917137	2.992417
114	3.074366	3.163151		115	3.081064	3.169710
115	3.272548	3.381945		116	3.278947	3.388185
116	3.527703	3.673462		117	3.533750	3.679315
117	3.903650	4.133838		118	3.909234	4.139152

ERROR   = 0.000195
ENTROPY = 6.570957

ERROR   = 0.000192
ENTROPY = 6.583136

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 119			N = 120		
J	X	Y	J	X	Y
60	-0.018092	0.000000	61	0.000000	0.017941
61	0.018092	0.036183	62	0.035886	0.053831
62	0.054283	0.072382	63	0.071787	0.089744
63	0.090497	0.108613	64	0.107720	0.125695
64	0.126752	0.144891	65	0.143698	0.161701
65	0.163062	0.181233	66	0.179739	0.197777
66	0.199444	0.217655	67	0.215858	0.233939
67	0.235914	0.254173	68	0.252071	0.270203
68	0.272489	0.290805	69	0.288395	0.306586
69	0.309186	0.327567	70	0.324845	0.343105
70	0.346022	0.364478	71	0.361441	0.379777
71	0.383016	0.401554	72	0.398198	0.416620
72	0.420185	0.438816	73	0.435136	0.453652
73	0.457549	0.476282	74	0.472273	0.490893
74	0.495127	0.513972	75	0.509628	0.528363
75	0.532940	0.551907	76	0.547222	0.566081
76	0.571008	0.590109	77	0.585075	0.604070
77	0.609354	0.628600	78	0.623210	0.642351
78	0.648002	0.667404	79	0.661650	0.680949
79	0.686975	0.706546	80	0.700419	0.719888
80	0.726299	0.746052	81	0.739542	0.759195
81	0.766001	0.785950	82	0.779045	0.798896
82	0.806110	0.826269	83	0.818959	0.839022
83	0.846656	0.867042	84	0.859312	0.879603
84	0.887671	0.908300	85	0.900138	0.920673
85	0.929191	0.950081	86	0.941470	0.962267
86	0.971251	0.992422	87	0.983345	1.004424
87	1.013893	1.035364	88	1.025804	1.047184
88	1.057159	1.078953	89	1.068888	1.090592
89	1.101094	1.123236	90	1.112644	1.134696
90	1.145750	1.168265	91	1.157123	1.179549
91	1.191182	1.214098	92	1.202378	1.225207
92	1.237448	1.260798	93	1.248469	1.271732
93	1.284615	1.308433	94	1.295463	1.319194
94	1.332755	1.357078	95	1.343431	1.367668
95	1.381948	1.406818	96	1.392452	1.417237
96	1.432283	1.457747	97	1.442616	1.467995
97	1.483857	1.509968	98	1.494020	1.520046
98	1.536783	1.563598	99	1.546776	1.573507
99	1.591185	1.618772	100	1.601009	1.628511
100	1.647205	1.675639	101	1.656860	1.685209
101	1.705005	1.734371	102	1.714490	1.743772
102	1.764770	1.795169	103	1.774085	1.804399
103	1.826716	1.858263	104	1.835860	1.867322
104	1.891094	1.923924	105	1.900066	1.932810
105	1.958199	1.992473	106	1.966997	2.001184
106	2.028383	2.064293	107	2.037006	2.072828
107	2.102071	2.139849	108	2.110517	2.148205
108	2.179780	2.219712	109	2.188045	2.227885
109	2.262153	2.304594	110	2.270233	2.312581
110	2.349998	2.395402	111	2.357889	2.403198
111	2.444359	2.493317	112	2.452056	2.500915
112	2.546617	2.599917	113	2.554113	2.607310
113	2.658652	2.717387	114	2.665937	2.724564
114	2.783132	2.848876	115	2.790195	2.855825
115	2.924031	2.999187	116	2.930857	3.005889
116	3.087695	3.176204	117	3.094262	3.182634
117	3.285284	3.394365	118	3.291559	3.400485
118	3.539739	3.685113	119	3.545671	3.690856
119	3.914764	4.144416	120	3.920244	4.149631

ERROR = 0.000189	ERROR = 0.000186
ENTROPY = 6.595213	ENTROPY = 6.607190

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 121			N = 122		
J	X	Y	J	X	Y
61	-0.017795	0.000000	62	0.000000	0.017649
62	0.017795	0.035590	63	0.035302	0.052955
63	0.053392	0.071195	64	0.070619	0.088283
64	0.089012	0.106830	65	0.105965	0.123648
65	0.124670	0.142510	66	0.141356	0.159064
66	0.160380	0.178251	67	0.176805	0.194547
67	0.196159	0.214067	68	0.212329	0.230111
68	0.232022	0.249976	69	0.247943	0.265774
69	0.267984	0.285993	70	0.283661	0.301549
70	0.304063	0.322133	71	0.319501	0.337453
71	0.340274	0.358415	72	0.355478	0.373503
72	0.376634	0.394854	73	0.391609	0.409715
73	0.413161	0.431469	74	0.427911	0.446107
74	0.449873	0.468278	75	0.464402	0.482698
75	0.486788	0.505299	76	0.501101	0.519505
76	0.523926	0.542553	77	0.538026	0.556548
77	0.561306	0.580059	78	0.575198	0.593847
78	0.598950	0.617840	79	0.612636	0.631424
79	0.636878	0.655917	80	0.650363	0.669301
80	0.675115	0.694313	81	0.688401	0.707500
81	0.713684	0.733054	82	0.726774	0.746047
82	0.752610	0.772165	83	0.765507	0.784967
83	0.791920	0.811674	84	0.804627	0.824287
84	0.831642	0.851610	85	0.844162	0.864037
85	0.871807	0.892003	86	0.884142	0.904247
86	0.912446	0.932888	87	0.924599	0.944951
87	0.953594	0.974300	88	0.965567	0.986183
88	0.995288	1.016276	89	1.007082	1.027982
89	1.037566	1.058857	90	1.049185	1.070338
90	1.080473	1.102089	91	1.091917	1.113446
91	1.124053	1.146018	92	1.135324	1.157203
92	1.168357	1.190697	93	1.179457	1.201711
93	1.213439	1.236182	94	1.224370	1.247028
94	1.259360	1.282537	95	1.270121	1.293215
95	1.306183	1.329829	96	1.316777	1.340340
96	1.353981	1.378133	97	1.364409	1.388478
97	1.402834	1.427535	98	1.413096	1.437714
98	1.452830	1.478125	99	1.462927	1.488140
99	1.504067	1.530009	100	1.514000	1.539860
100	1.556657	1.583304	101	1.566426	1.592991
101	1.610723	1.638141	102	1.620328	1.647665
102	1.666407	1.694672	103	1.675848	1.704031
103	1.723870	1.753068	104	1.733147	1.762263
104	1.783298	1.813527	105	1.792410	1.822557
105	1.844904	1.876281	106	1.853851	1.885145
106	1.908941	1.941600	107	1.917720	1.950296
107	1.975701	2.009803	108	1.984313	2.018330
108	2.045538	2.081273	109	2.053979	2.089628
109	2.118873	2.156473	110	2.127142	2.164655
110	2.196224	2.235974	111	2.204317	2.243979
111	2.278230	2.320486	112	2.286144	2.328310
112	2.365700	2.410914	113	2.373431	2.418552
113	2.459675	2.508436	114	2.467217	2.515882
114	2.561532	2.614629	115	2.568878	2.621874
115	2.673150	2.731670	116	2.680290	2.738706
116	2.797188	2.862705	117	2.804112	2.869518
117	2.937616	3.012526	118	2.944308	3.019098
118	3.100764	3.189003	119	3.107204	3.195310
119	3.297775	3.406547	120	3.303931	3.412551
120	3.551546	3.696545	121	3.557366	3.702182
121	3.925672	4.154798	122	3.931050	4.159918

ERROR =	0.000183	ERROR = 0.000180
ENTROPY =	6.619068	ENTROPY = 6.630849

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 123			N = 124		
J	X	Y	J	X	Y
62	-0.017508	0.000000	63	0.000000	0.017367
63	0.017508	0.035015	64	0.034737	0.052107
64	0.052530	0.070045	65	0.069488	0.086869
65	0.087575	0.105104	66	0.104267	0.121665
66	0.122655	0.140206	67	0.139088	0.156511
67	0.157785	0.175365	68	0.173966	0.191420
68	0.192981	0.210597	69	0.208914	0.226408
69	0.228256	0.245916	70	0.243947	0.261487
70	0.263627	0.281338	71	0.279081	0.296675
71	0.299108	0.316877	72	0.314330	0.331985
72	0.334714	0.352551	73	0.349709	0.367434
73	0.370463	0.388375	74	0.385236	0.403037
74	0.406370	0.424366	75	0.420925	0.438812
75	0.442453	0.460541	76	0.456793	0.474775
76	0.478729	0.496918	77	0.492859	0.510943
77	0.515217	0.533515	78	0.529140	0.547336
78	0.551934	0.570353	79	0.565654	0.583972
79	0.588901	0.607450	80	0.602422	0.620871
80	0.626139	0.644828	81	0.639463	0.658054
81	0.663668	0.682509	82	0.676799	0.695543
82	0.701512	0.720515	83	0.714452	0.733361
83	0.739693	0.758872	84	0.752446	0.771532
84	0.778238	0.797604	85	0.790806	0.810081
85	0.817172	0.836740	86	0.829558	0.849035
86	0.856524	0.876307	87	0.863730	0.888424
87	0.896322	0.916338	88	0.908351	0.928278
88	0.936600	0.956863	89	0.948454	0.968630
89	0.977392	0.997920	90	0.989072	1.009514
90	1.018732	1.039545	91	1.030241	1.050968
91	1.060662	1.081779	92	1.072001	1.093034
92	1.103223	1.124667	93	1.114394	1.135754
93	1.146461	1.168255	94	1.157465	1.179177
94	1.190426	1.212596	95	1.201265	1.223354
95	1.235171	1.257747	96	1.245847	1.268341
96	1.280757	1.303768	97	1.291271	1.314201
97	1.327249	1.350730	98	1.337601	1.361001
98	1.374717	1.398705	99	1.384908	1.408816
99	1.423242	1.447779	100	1.433273	1.457730
100	1.472911	1.498043	101	1.482782	1.507835
101	1.523822	1.549601	102	1.533535	1.559235
102	1.576086	1.602571	103	1.535640	1.612045
103	1.629827	1.657083	104	1.639222	1.666399
104	1.685186	1.713288	105	1.694422	1.722445
105	1.742323	1.771358	106	1.751400	1.780355
106	1.801424	1.831490	107	1.810341	1.840327
107	1.862702	1.893914	108	1.871459	1.902590
108	1.926407	1.958900	109	1.935002	1.967414
109	1.992834	2.026767	110	2.001265	2.035117
110	2.062332	2.097897	111	2.070599	2.106081
111	2.135325	2.172753	112	2.143424	2.180767
112	2.212327	2.251902	113	2.220256	2.259744
113	2.293978	2.336054	114	2.301732	2.343720
114	2.381083	2.426112	115	2.388659	2.433598
115	2.474683	2.523253	116	2.482074	2.530551
116	2.576151	2.629048	117	2.583351	2.636151
117	2.687360	2.745673	118	2.694361	2.752572
118	2.810969	2.876265	119	2.817759	2.882947
119	2.950936	3.025608	120	2.957501	3.032055
120	3.113583	3.201558	121	3.119901	3.207746
121	3.310029	3.418500	122	3.316069	3.424392
122	3.563133	3.707766	123	3.568845	3.713299
123	3.936379	4.164992	124	3.941659	4.170020

ERROR = 0.000177			ERROR = 0.000174		
ENTROPY = 6.642534			ENTROPY = 6.654126		

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 125			N = 126		
J	X	Y	J	X	Y
63	-0.017230	0.000000	64	0.000000	0.017093
64	0.017230	0.034459	65	0.034189	0.051286
65	0.051696	0.068933	66	0.068393	0.085499
66	0.086183	0.103433	67	0.102622	0.119746
67	0.120704	0.137975	68	0.136892	0.154039
68	0.155273	0.172571	69	0.171216	0.188393
69	0.189904	0.207237	70	0.205607	0.222821
70	0.224611	0.241986	71	0.240080	0.257338
71	0.259409	0.276832	72	0.274647	0.291957
72	0.294312	0.311791	73	0.309325	0.326693
73	0.329334	0.346878	74	0.344127	0.361561
74	0.364492	0.382107	75	0.379068	0.396576
75	0.399801	0.417495	76	0.414165	0.431754
76	0.435277	0.453058	77	0.449432	0.467111
77	0.470936	0.488814	78	0.484887	0.502663
78	0.506796	0.524779	79	0.520546	0.538429
79	0.542875	0.560971	80	0.556427	0.574426
80	0.579191	0.597410	81	0.592549	0.610672
81	0.615763	0.634116	82	0.628930	0.647188
82	0.652612	0.671109	83	0.665592	0.683995
83	0.689759	0.708410	84	0.702553	0.721112
84	0.727226	0.746043	85	0.739838	0.758564
85	0.765037	0.784031	86	0.777469	0.796374
86	0.803216	0.822400	87	0.815470	0.834567
87	0.841789	0.861178	88	0.853869	0.873170
88	0.880785	0.900392	89	0.892691	0.912212
89	0.920232	0.940072	90	0.931968	0.951724
90	0.960163	0.980253	91	0.971730	0.991736
91	1.000610	1.020968	92	1.012011	1.032286
92	1.041612	1.062255	93	1.052847	1.073409
93	1.083205	1.104155	94	1.094277	1.115146
94	1.125433	1.146711	95	1.136343	1.157541
95	1.168341	1.189971	96	1.179091	1.200641
96	1.211979	1.233987	97	1.222569	1.244498
97	1.256400	1.278814	98	1.266833	1.289167
98	1.301664	1.324514	99	1.311939	1.334711
99	1.347835	1.371156	100	1.357954	1.381197
100	1.394985	1.418814	101	1.404949	1.428700
101	1.443192	1.467570	102	1.453001	1.477302
102	1.492545	1.517519	103	1.502200	1.527097
103	1.543141	1.568762	104	1.552642	1.578187
104	1.595090	1.621417	105	1.604437	1.630687
105	1.648516	1.675614	106	1.657709	1.684731
106	1.703559	1.731504	107	1.712599	1.740467
107	1.760381	1.789257	108	1.769266	1.798065
108	1.819164	1.849071	109	1.827895	1.857724
109	1.880123	1.911176	110	1.888698	1.919672
110	1.943507	1.975839	111	1.951925	1.984178
111	2.009610	2.043381	112	2.017869	2.051560
112	2.078780	2.114180	113	2.086879	2.122198
113	2.151440	2.188700	114	2.159376	2.196554
114	2.228104	2.267508	115	2.235874	2.275194
115	2.309409	2.351310	116	2.317009	2.358825
116	2.396159	2.441009	117	2.403586	2.448347
117	2.489393	2.537778	118	2.496641	2.544934
118	2.590482	2.643186	119	2.597543	2.650152
119	2.701295	2.759404	120	2.708162	2.766171
120	2.824484	2.889565	121	2.831145	2.896120
121	2.964003	3.038441	122	2.970444	3.044768
122	3.126159	3.213877	123	3.132360	3.219951
123	3.322054	3.430231	124	3.327984	3.436016
124	3.574506	3.718781	125	3.580115	3.724215
125	3.946893	4.175004	126	3.952079	4.179943

ERROR = 0.000171	ERROR = 0.000169
ENTROPY = 6.665625	ENTROPY = 6.677034

TABLE 1

MAX'S QUANTIZER PARAMETERS FOR THE NORMAL DISTRIBUTION (CONT'D.)

N = 127				N = 128		
J	X	Y		J	X	Y
64	-0.016961	0.000000		65	-0.000001	0.016828
65	0.016960	0.033921		66	0.033659	0.050490
66	0.050888	0.067855		67	0.067331	0.084172
67	0.084835	0.101815		68	0.101029	0.117886
68	0.118814	0.135814		69	0.134765	0.151644
69	0.152840	0.169865		70	0.168552	0.185460
70	0.186924	0.203983		71	0.202404	0.219347
71	0.221081	0.238180		72	0.236333	0.253318
72	0.255325	0.272470		73	0.270353	0.287387
73	0.289668	0.306867		74	0.304477	0.321567
74	0.324126	0.341385		75	0.338720	0.355874
75	0.358712	0.376040		76	0.373097	0.390320
76	0.393443	0.410845		77	0.407620	0.424921
77	0.428332	0.445818		78	0.442307	0.459693
78	0.463396	0.480973		79	0.477172	0.494651
79	0.498650	0.516328		80	0.512231	0.529812
80	0.534113	0.551899		81	0.547502	0.565192
81	0.569801	0.587704		82	0.583001	0.600810
82	0.605733	0.623762		83	0.618747	0.636684
83	0.641927	0.660093		84	0.654758	0.672833
84	0.678404	0.696716		85	0.691055	0.709277
85	0.715185	0.733654		86	0.727658	0.746039
86	0.752291	0.770928		87	0.764589	0.783139
87	0.789746	0.808563		88	0.801871	0.820602
88	0.827573	0.846584		89	0.839528	0.858454
89	0.865800	0.885016		90	0.877587	0.896719
90	0.904453	0.923890		91	0.916074	0.935428
91	0.943563	0.963235		92	0.955019	0.974609
92	0.983159	1.003083		93	0.994453	1.014296
93	1.023276	1.043470		94	1.034409	1.054523
94	1.063950	1.084431		95	1.074924	1.095326
95	1.105220	1.126009		96	1.116037	1.136747
96	1.147127	1.168246		97	1.157788	1.178828
97	1.189717	1.211189		98	1.200223	1.221617
98	1.233039	1.254890		99	1.243391	1.265165
99	1.277147	1.299404		100	1.287346	1.309527
100	1.322099	1.344794		101	1.332146	1.354766
101	1.367961	1.391127		102	1.377857	1.400948
102	1.414802	1.438478		103	1.424548	1.448148
103	1.462703	1.486928		104	1.472299	1.496450
104	1.511750	1.536571		105	1.521196	1.545943
105	1.562040	1.587509		106	1.571338	1.596733
106	1.613684	1.639859		107	1.622833	1.648933
107	1.666805	1.693751		108	1.675805	1.702677
108	1.721543	1.749335		109	1.730394	1.758111
109	1.778058	1.806781		110	1.786759	1.815407
110	1.836534	1.866287		111	1.845085	1.874762
111	1.897184	1.928081		112	1.905583	1.936404
112	1.960256	1.992431		113	1.968503	2.000601
113	2.026044	2.059656		114	2.034136	2.067671
114	2.094896	2.130135		115	2.102832	2.137993
115	2.167232	2.204329		116	2.175010	2.212027
116	2.243566	2.282804		117	2.251183	2.290339
117	2.324534	2.366265		118	2.331986	2.373634
118	2.410940	2.455614		119	2.418222	2.462811
119	2.503818	2.552021		120	2.510926	2.559040
120	2.604536	2.657052		121	2.611463	2.663886
121	2.714963	2.772874		122	2.721700	2.779514
122	2.837744	2.902614		123	2.844280	2.909047
123	2.976825	3.051036		124	2.983146	3.057246
124	3.138503	3.225970		125	3.144589	3.231933
125	3.333859	3.441749		126	3.339681	3.447430
126	3.585674	3.729599		127	3.591183	3.734936
127	3.957220	4.184840		128	3.962315	4.189694

N = 127: ERROR = 0.000166   ENTROPY = 6.688352

N = 128: ERROR = 0.000163   ENTROPY = 6.699583

APPENDIX A

PROGRAM LISTING TO SOLVE FOR LLOYD-MAX QUANTIZER PARAMETERS BY THE METHOD OF SUCCESSIVE SUBSTITUTION

```
C THIS PROGRAM CALCULATES LLOYD-MAX QUANTIZER PARAMETERS BY THE METHOD
C OF SUCCESSIVE SUBSTITUTION FOR THE NORMAL DISTRIBUTION OF ZERO MEAN
C AND UNIT VARIANCE
C The INPUT TO THE PROGRAM IS
C    (1)     THE NUMBER OF QUANTIZATION LEVELS    N
C    (2)     THE MAXIMUM NUMBER OF ITERATIONS     M
C    (2)     THE ACCURACY                         AP
C            *****************************
      REAL*8 X(199),T(199),XX(199),TT(199),C ,DELTA,AP(199),AP
     1,ERROR,ENTROP
      INTEGER K,N,I,P,N1,N2,N3,M
      C=DSQRT(00.50D0/DATAN(1.0D0))
C     DO 99 N=110,110
C********************************************************************
C  INPUT THE NUMBER OF QUANTIZATION LEVELS
      N=100
      WRITE(9,65)N
      WRITE(9,66)
      WRITE(9,67)
      WRITE(9,66)
C***********************************************************************
C     INITIALIZATION OF THE QUANTIZER PARAMETERS
C
      DELTA=0.0150D0*DFLOAT(N)
      XX(1)=-10.50000D0
      TT(1)=-5.50000D0
      X(1)=XX(1)
      T(1)=TT(1)
      DO 50  L=2,N
          TT(L)=TT(L-1)-DELTA
          XX(L)=(TT(I)+TT(I-1))/2.0D0
          X(L)=XX(L)
          T(L)=TT(L)
 50   CONTINUE
C**********************************************************************
C     BEGINING OF THE ITERATIONS
c     M = MAXIMUM NUMBER OF ITERATIONS
      M = 1050
      K=0
 5    K=K+1
      IF (K .GT. M) GO TO 10
       IF (K .GT. 1)X(N)=XX(N)
       IF (K .GT. 1)T(N)=TT(N)
       TT(1)=-C*DEXP(-XX(2)*XX(2)/2.0D0)/(DERFC(-10.0D0)-
     1DERFC(XX(2)/DSQRT(2.0D0)))
       T(1)=TT(1)
       IF ( N .EQ. 2 ) GO TO 17
        DO 15  P=2,N-1
            XX(P)=(T(P)+T(P-1))/2.0D0
            X(P)=XX(P)
            TT(P)=DEXP(-X(P)*X(P)/2.0D0)-DEXP(-X(P+1)*X(P+1)/2.0D0)
            TT(P)=TT(P)*C/(DERFC(X(P)/DSQRT(2.0D0))-DERFC(X(P+1)/DSQRT(2.0
     1      0D0)))
            T(P)=TT(P)
 15         CONTINUE
 17         CONTINUE
        XX(N)=(TT(N)+T(N-1))/2.0D0
       TT(N)=DEXP(-XX(N)*XX(N)/2.0D0)*C/DERFC(XX(N)/DSQRT(2.0D0))
       X(N)=XX(N)
       T(N)=TT(N)
```

52

```
            N2=IDINT(DFLOAT((N+2)/2))
            N1=IDINT(DFLOAT((N+1)/2))
C*****************************************************
C      CHECKING THE PRECISION OF THE SOLUTION
c      AP = REQUIRED ACCURACY
         AP=0.10D-6
         IF((MOD(N,2) .EQ. 0).AND.(DABS(X(N2)).GT. AP))GO TO 5
         IF((MOD(N+1,2) .EQ. 0).AND. (DABS(T(N1)).GT. AP))GO TO 5
            CONTINUE
  10      CONTINUE
C*****************************************************
C      OUTPUT RESULTS
         IF (MOD(N,2)  .EQ. 0)N3=N2
         IF (MOD(N+1,2) .EQ. 0)N3=N1
         WRITE(6,60) K
         DO 120 J=1,N3
              IF (J .EQ. 1)
     1      WRITE(9,71)J, T(J)
              IF (J .GT. 1)
     1      WRITE(9,61)J, X(J),T(J)
  120     CONTINUE
         X(N+1)=10.0D0
         X(1)=-10.0D0
         ERROR=0.0D0
         ENTROP=0.0D0
         DO 222 I=1,N
              AP(I)=DERFC(X(I)/DSQRT(2.0D0))-DERFC(X(I+1)/DSQRT(2.0D0))
              AP(I)=AP(I)/2.0D0
              ERROR=ERROR+AP(I)*T(I)**2
              ENTROP=ENTROP-AP(I)*DLOG(AP(I))/DLOG(2.0D0)
  222     CONTINUE
         ERROR=1.0D0-ERROR
         WRITE(9,66)
         WRITE(9,62) ERROR
         WRITE(9,66)
         WRITE(9,63) ENTROP
         WRITE(9,66)
         WRITE(6,72) K
         WRITE(9,90)
         WRITE(9,66)
C99     CONTINUE
  65     FORMAT(3X,'  N = ',I7)
  66     FORMAT(3X,'--------------------------')
  67     FORMAT(3X,' J         X          Y      ')
  60     FORMAT(1X,I7,8(1X,F6.4))
  90     FORMAT(2X,'=========================================')
  61     FORMAT(1X,I4, 2(2X,F9.6))
  71     FORMAT(1X,I4,11X, 2(2X,F9.6))
  62     FORMAT(7X,'ERROR   =', 2(1X,F9.6))
  72     FORMAT(3X,'# ITERATIONS = ',I7 )
  63     FORMAT(7X,'ENTROPY =', 2(1X,F9.6))
         STOP
         END
```

REFERENCES

1. Lloyd, S. P., "Least Squares Quantization in PCM," Unpublished Bell Laboratories manuscript, July 31, 1957; also in *IEEE Trans. on Inform. Theory*, vol. IT-28, pp. 129-137, 1982.

2. Max,J., "Quantization for Minimum Distortion", *IRE Trans. on Inform. Theory*, vol. IT-6,pp. 7-13,1960.

3. Pearson ,C. E.,Numerical Methods in Engineering and Science, pp.11-12 and 49-50, Van Nostrand Reinhold Company, New York, 1986.

4. Kassam, S. A., "Optimal Quantization for Signal Detection", *IEEE, Trans. on Communication*, vol. COM-25, No. 5,May 1977,pp. 479-484.

5. Al-Bassiouni, A.M., *Optimum Signal Processing in Distributed Sensor Systems*, Ph. D. Dissertation at the Naval Postgraduate School, Dec. 1987.

6. Wood. C. R., "On Optimum Quantization", *IEEE Trans. on Information Theory*, vol. IT-15, No.2, March 1969.

7. Velichkin, A. I., "Optimum Characteristics of Quantizers," *Telecommunication Radio Eng. (USSR)*, vol. 18, Feb. 1963, pp.1-7.

8. Garmash,V. A., "The Quantization of Signals with Non-uniform Steps," *Telecommunications*. No. 10, pp. 10-12, Oct., 1957.

INITIAL DISTRIBUTION LIST